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18TH ONTARIO INDUSTRIAL WASTE CONFERENCE

JUNE 13-16, 1971
NIAGARA FALLS, ONTARIO

PROCEEDINGS

Water management in Ontario

SPONSORED BY
ONTARIO WATER RESOURCES COMMISSION

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C O N T E N T S

P R E F A C E

D. S. Caverly,
General Manager,
Ontario Water Resources Commission.

Conference Chairman.

The 1971 Ontario Industrial Waste Conference, held at the Sheraton-Brock Hotel in Niagara Falls, Ontario, attracted an attendance of approximately 350 people. This was our eighteenth conference and I would like to express, on behalf of the Conference Committee, our sincere appreciation of your participation in helping to make this, once again, a successful meeting.

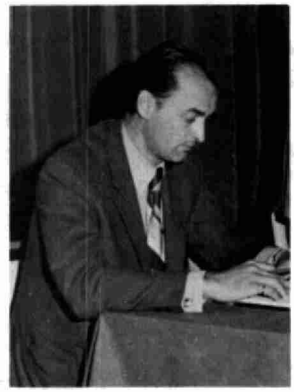
Conferences of this kind play an important part in fostering the exchange of ideas and information on the solution to industrial waste problems. I am pleased to forward to you a copy of the 1971 Proceedings and you will, I am sure, find these papers both useful and informative. I wish to extend my thanks to the authors for their contribution to the success of this Conference.

Any information required regarding our next year's Conference, or information on Proceedings generally, may be obtained by writing to the Ontario Water Resources Commission at 135 St. Clair Avenue West, Toronto 7, Ontario.

I trust you found the Conference interesting and enjoyable and hope we may see you again next year.

Conference Chairman.

SESSION CHAIRMAN,
MR. EUGENE E. KUPCHANKO,
HEAD, WATER POLLUTION CONTROL BRANCH,
DEPARTMENT OF THE ENVIRONMENT,
EDMONTON, ALBERTA.



W.J.H. Stuart

"THE DEVELOPMENT AND COORDINATION OF CONTINGENCY PLANNING ACTIVITIES IN THE FEDERAL GOVERNMENT"

BY

CAPTAIN W.J.H. STUART,
POLLUTION CONTROL OFFICER

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OTTAWA.

The subject of my paper is the involvement of the Federal Government of Canada in the contingency planning to deal with major incidents of water pollution, and I address myself specifically to the activities of the Ministry of Transport of which I am an official.

There are many definitions of 'pollution' - some are good and some are not quite so good. I prefer that given by Lord Kennet in his Fabian Society paper which defines 'pollution' as "the presence at large of substances or energy patterns which have been involuntarily produced by man or, though voluntarily

produced, have achieved their purposes, have escaped by accident in quantities which harm or may harm his health or do offend him."

A 'contingency' is an occurrence which <u>may</u> happen hereafter and the planning is the function to prepare for the advent of the uncertain, and yet anticipated, contingency which poses a threat to the quality of life within the context of my paper.

Mankind is becoming increasingly aware of and angry at the deterioration in the quality of those things which are deemed vital to his survival on the planet. He recognizes the overwhelming measure of the problem with which he is faced is self-inflicted; this has generated national and international demand that positive steps be taken to ameliorate the situation.

Environmental crises are caused by man's imperception and imperfection and can be resolved by his ingenuity. There are several ways in which those who bear responsibility can respond to the increasing pressure to at least halt this steady deterioration in natural resource quality and to establish a level of pollution which can be adequately dealt with by that much overworked, but incredibly flexible, lady, Mother Nature. No matter how hard we try, it must be accepted that we will be unable to achieve the Utopian State wherein it could be guaranteed no pollution would take place as a result of an extensive program of prophylaxis. Occurrences/contingencies are inevitable in the normal courses of the complex society in which we live, which will present threats in varying degrees to our human society. Hence those who bear responsibility or a measure of commitment must prepare themselves in such a manner, so as the threat of major incidents of pollution will have a minimal impact upon our society.

I do not intend to go into very much detail as to how the Minister of Transport became involved in contingency planning for pollution incidents. Suffice it to say the Ministry had a long involvement in the prevention of pollution from ships, which are very tangible targets, and had had some awkward experiences in disposing of cargoes and bunkers in ships which had been hazarded. In a 1969 amendment to the Canada Shipping Act, power was given to the Minister to "cause a vessel, its cargo or fuel to be destroyed or removed to such a place, and sold in such a

manner as he may direct". In a sense there was recognized in this an implicit responsibility to become involved in the clean-up process subsequent to the loss of a vessel, in addition to the historical regulatory process to prevent such losses. Then the "Arrow" took the ground on 4 February 1970, in Chedabucto Bay, Nova Scotia. The Minister reacted immediately and this incident has been the catalyst which has caused the further development of Federal involvement.

In the early summer of 1970 a committee was formed in Ottawa representing all the Federal agencies which have an operational interest in the preparation of a Federal contingency plan. By July 1970, such a plan had been prepared and issued as an interim measure. It was recognized that it was essential to establish immediately a framework of Federal capability to react to incidents of catastrophic proportions, even though the answer may not be an engineer's blueprint. Despite misgivings, the interim plan has been a success beyond our anticipations. It perhaps proves the motivation of all the agencies having an involvement in that they have made it work, which is the ultimate achievement of any plan. We must now go on and improve our first effort, thereby recognizing and confirming to the dynamism of our age.

In essence, the Federal plan provides for the establishment and naming of Federal officials who have a responsibility for coordination within their own designated areas. We anticipate that, within their own areas, these officials will be heavily involved in preparing their own local contingency plans and seeking support of the several levels of government and industry within their own areas. It would be unrealistic for the Federal plan to attempt to contain the specific local plans across the length and breadth of our land. These local plans must be prepared under the umbrella of a national plan.

The Federal intent is to leave the evaluation of a problem in the hands of those most suited with the local knowledge. It does provide for the escalation of the response to the full commitment of all the Federal resources which may be needed if the incident is patently beyond the capability of other levels of government, and if it is asked for. It must be appreciated that the early evaluation of catastrophic proportions and an early request for help is of paramount importance. As Doctor McTaggart-Cowan says, a delay in the full recognition of the potential

problem will turn the operation into a Dunkirk. It is a human reaction that few wish to concede defeat; however, in such incidents the urgency is to be realistic and practical and to endeavour not to let the situation get out of hand. Of course, it is possible that the situation could be out of hand almost immediately by the very nature of the incident and the demand then is to lessen, as much as possible, the impact upon an innocent but vulnerable society.

I would put it to you that there are three distinctive phases in contingency planning for this type of threat.

Phase I - Planning, Preparation and the Evaluation of the threat and equipment and resource structure needed to deal with it.

Phase II - The clean-up or janitor process.

Phase III - The aftermath and the re-evaluation of the operation to improve the posture, techniques, etc.

Phase III has come to be recognized as a problem area which can become a long drawn-out process extending over many years. If a major pollution incident occurs, it has the potential of having a very profound impact upon the social, economic, and political outlook and well-being of the segment of society which is most directly affected. Any contingency organization must acknowledge, and be prepared to compete with, the many difficult situations which will arise after the clean-up operation has been completed to the best of the ability of those who are responsible for the janitor process.

I do not intend to repeat the conclusions and recommendations of Doctor McTaggart-Cowan, Doctor Sheffer and Captain Martin, made subsequent to their outstanding achievements in the "Arrow" incident, which they have documented so well. I recommend the reading of all three volumes of their report to anyone with an involvement in this subject. Suffice it to say that scientific, technical and operational capability and input are fundamental to the success of any contingency planning and operation.

The financial and legal implications in total must be understood by the contingency team command structure. It is an

unfortunate realism and it is something over which that team have little or no control. These are factors which must be the subject of review by the top management, and the decision-making process and their resolutions incorporated in the plan for the guidance of those who have to manage the operation.

My paper has perhaps strayed somewhat from the specific of federal contingency planning but I felt sure that you would be interested in some of the lessons we have learned in the process of our examination of the problem. There are other problems which you will most certainly recognize and I am prepared to discuss these with you in the question period.

In concert with the Government of the Province of Ontario and the Government of the United States, we have produced a draft contingency plan for the Great Lakes area which should provide for mutual support and operations in the area of the Great Lakes. A Field Manual for the guidance of the on-scene contingency commanders has also been produced and issued. It is difficult to find individuals with any extensive knowledge or background in this subject and we felt obligated to provide as much assistance as possible in preparing them for the exercise of their task.

In final, I would like to make the point, with considerable pleasure, that the cooperation, support and able input of the Government of Ontario and their appointed officials have been quite outstanding and a unique contribution to the resolution of the very difficult problem of preparing ourselves for a contingency.

K.H. Shikaze

"THE DEVELOPMENT AND COORDINATION OF CONTINGENCY PLANNING ACTIVITIES IN THE ONTARIO GOVERNMENT"

BY

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The Province of Ontario, blessed with abundant water resources ranging from the Great Lakes to smaller inland lakes, from large rivers to small streams, must constantly be on the alert to protect these waters from all sources of contamination. An increasing threat and of alarming concern are the accidental, or otherwise, spills which result in the discharge of petroleum products or other hazardous materials to our waters. To minimize the effects of these spills, contingency measures must be developed so that rapid and clearly coordinated action can be taken by all the parties concerned.

Lake Erie Contingency Plan

In Ontario, the development of contingency planning activities began in late 1969 and the initial contingency plan developed was for Lake Erie in April 1970.

This plan received priority because of the concern being expressed about the oil and gas well drilling operations on the lake and the recommendations of the IJC which strongly recommended that contingency measures were essential if these operations were to be allowed to continue on the lake. The Lake Erie Contingency Plan outlined the role of the respective government agencies, (Ontario Water Resources Commission, Ontario Department of Mines and Northern Affairs, Ontario Department of Lands and Forests, Ontario Department of Health, Ontario Provincial Police and Canada Ministry of Transport) under what circumstances the plan would be placed into effect, defined the chain of command so that orderly operations would be effected, outlined the communications necessary to provide not only an alerting and notification system for spill incidents but also for use at the scene of a spill and an inventory for all materials such as equipment and chemicals available that could be used in the event of a spill.

It should be emphasized at this point that the Lake Erie Contingency Plan as such and for that matter, any contingency plan, does not detail what one should do, what to use or how to use specialized equipment in the event of a spill. Each spill is a different situation requiring different actions and it would be impossible to provide detailed procedures for each type of incident that might occur. Moreover, very few people in Ontario let alone in Canada have had experience in dealing with a variety of spill incidents. One can only hope that the limited procedures delineated in contingency plans clarify the chain of command and provide those on the scene with sufficient information so that they can proceed without delays with the orderly cleanup of a spill. Every effort is being made to keep involved personnel up-to-date on developments on how to combat spills, on new equipment that is available, on improved communications and surveillance procedures.

Province of Ontario Contingency Plan

The Province of Ontario Contingency Plan in its preliminary form was completed in October 1970 and forwarded to many interested parties both in and out of government who were invited to comment on its contents. A number of

comments were received from other government departments and from the petroleum industry. These comments were incorporated into the Interim Province of Ontario Contingency Plan. The plan is interim because it became apparent that the complete resources available within the provincial government departments to cope with emergency situations were not being utilized to the maximum degree and it was decided necessary to solicit more complete participation from these departments. As a result, an Interdepartmental Task Force on Contingency Planning has been established within the Provincial Government and it will be their responsibility to continually review and update the Province of Ontario Contingency Plan and to ensure that each department is completely aware of its responsibility upon implementation of the contingency plan. The Provincial Departments represented are the Ontario Water Resources Commission, Department of Lands and Forests, Department of Highways, Department of Mines and Northern Affairs, Department of Health, Department of Justice, Department of Labour and the Department of Energy and Resources Management. The Federal Government and industry will also be represented.

As it now stands, the interim plan provides a framework for spill discovery and reporting as well as for the coordination and command of the available resources of manpower, materials and equipment to control and cleanup a spill. The plan applies to all major spill incidents. Major spill incidents are defined as those spills which cannot be controlled through local industry or cooperative contingency plans, the formation and organization of which will be discussed later in this paper.

Spill Discovery and Notification

Spill discovery and notification are the first response actions to spills. Discovery of spills may be the result of deliberate searching procedures. At the present time, the Federal Ministry of Transport conducts regular surveillance flights over the lower Great Lakes to check for spills from vessels. The OWRC carries out random surveillance flights checking on both lake traffic and shore-based facilities. The U.S. Coast Guard also maintains regular surveillance for spills on the Great Lakes and many reports are received from this source. While a number of spill incidents are noted through these deliberate searching procedures, random discovery accounts for the majority of spill reports. Random discovery of spills may result from various government agencies whose activities require them to be on provincial waters,

from the shipping and fishing industries, from harbour commissions and boards, from municipal officials, from the public-at-large or from shore-based industry whether or not they were responsible for the spill.

It should be noted at this point that a recent amendment to the OWRC Act now makes it mandatory for a municipality or person that discharges or permits the discharge of any material of any kind and such discharge is not in the normal course of events or from whose control material of any kind escapes into any watercourse that may impair the quality of water of the watercourse, to notify the Commission of the discharge or escape. Failure to notify the Commission of such discharges can result upon summary conviction in a fine of not more than $5,000.

Industries and municipalities have been made aware of this new provision in the OWRC Act and needless to say this has resulted in a larger number of spill incidents being reported directly to the Commission by the person responsible. No incidents to date have required implementation of the Province of Ontario Contingency Plan as most of the spills have been minor in nature. Where cleanup or other remedial action has been required, it has been carried out by the person responsible for the spill to the satisfaction of the OWRC.

There is one deficiency in the foregoing legislation and that relates to the time lapse between spill occurrence and the subsequent reporting to the OWRC. Theoretically, the report need not be made to the OWRC for days after the incident has occurred and by this time severe damage could result if no remedial action has been taken. For the most part, however, spill reports have been received by the OWRC within hours after the incident has occurred.

Ontario Operations Center

Under the Province of Ontario Contingency Plan, there has been developed an Ontario Operations Center which serves as the focal point for all spill reports. The Ontario Operations Center also has other functions which will be described later. All spill reports should ultimately

reach the Operations Center where the information will be assessed to determine whether it will require the placing into effect of the Province of Ontario Contingency Plan. The Ontario Operations Center will then contact the other agencies who may be concerned and may become involved. The Center is equipped with a 24-hour telephone number (416) 365-2537 and a list of persons to be contacted is available for after-hours.

It is recognized in many areas throughout the Province that local arrangements have been made between industry personnel and OWRC Regional Office staff with regard to the reporting of spills. Insofar as the Regional staff are often in the best position to assess the impact of the spill and further since staff in the region will be the persons responsible for the surveillance and subsequent command functions if the Province of Ontario Contingency Plan is placed into effect, this arrangement will continue to exist. Provisions have been made to channel spill information received in this manner to the Ontario Operations Center.

Hopefully, few if any of the spill incidents reported will require full implementation of the Province of Ontario Contingency Plan. However, there are many other functions outlined in the plan that will be utilized for many spill incidents. The most utilized function will be that of the Operations Center since it will be the focal point for all spill reports and the location from which the subsequent investigation of the spill report will be directed. The Operations Center will maintain an up-to-date listing of inventory of materials and equipment in the Province that can be used to combat spills and will also keep abreast of new developments and techniques in spill control. In this way, staff of the Center can provide valuable technical assistance on all spill incidents.

On-Scene Coordination

To provide for the coordination of activities to combat a spill, the plan designates on-scene commanders (OSC) whose duty it will be to take complete charge of all activities related to the spill incident. It will be his responsibility to implement as quickly and effectively as possible

the plan so that the pollutional effects of the spill can be kept to a minimum. The on-scene commander is the person responsible for assessing the magnitude of the problem and for establishing the priorities for the protection of resources in the spill area. He will command the deployment of all available resources of manpower and equipment for the containment, countermeasures, cleanup, restoration and disposal functions. The Province of Ontario Contingency Plan has predesignated the on-scene commanders for seven areas of the Province.

The on-scene commander is supported by a Regional Operations Team which serves as the technical team on the scene and advises the on-scene commander on such matters as applicable control techniques, available materials, manpower, dangers to public health, fish, aquatic life and wildlife, navigation, etc. The Regional Operations Team is made up of representatives of all the interested government departments and depending on the area, may also have a representative of the Federal Government and industry. To date, the specific members of the Regional Operations Team for each area have not been named and this will be one of the priority items to be dealt with by the Interdepartmental Task Force. Once named, all members of the Regional Operations Team will be acquainted through seminars on the many aspects of spill control, containment and cleanup. Each member of the Regional Operations Team will be responsible for a specific function upon implementation of the contingency plan. In a further attempt to ensure effective coordination at the time of spill crisis, the on-scene commanders will be requested to call together the operations team in his area to review not only each member's responsibilities in the event of a major spill but to review potential sources of spills in the area.

The foregoing has outlined some of the action functions of the Province of Ontario Contingency Plan should it be placed into effect. The plan, however, also contains considerable background information that is required in the event of a major spill incident. Much of this information is also useful when dealing with routine spill incidents. This information includes procedures for reporting information and collecting samples, guidelines respecting the use of

chemicals for oil spills, detailed data on water intakes and recreational areas that may be affected and an inventory of equipment and other materials that can be used for spill control that are available in Ontario and the neighbouring states.

Spill Definition

The magnitude of the spill incident will dictate the degree of response by the concerned parties. In the case of a massive spill involving say a tanker on the Great Lakes, a federal response would most certainly be involved with provincial authorities providing support. If a spill crosses the international boundary and affects U.S. waters, then a coordinated international response would be required. Spill incidents affecting federal lands such as national parks, would also involve federal participation. The federal government could also be requested by the Province to provide technical and physical assistance for a major spill incident confined to provincial waters. In most of the foregoing instances, the response activities would come under federal command but the Province would be intimately involved so that its interests would be maintained.

A major spill could be described as one which requires the implementation of the Province of Ontario Contingency Plan. Such an incident would be one which could not be handled through the facilities of a local or area cooperative contingency planning group or it could be a spill incident of undetermined origin in an area where no cooperative contingency plan exists.

A moderate spill would be an incident requiring the resources of a cooperative or area contingency plan for control and cleanup. Provincial authorities would act only in an advisory capacity and provide assistance only when requested.

A minor spill is classified as an incident which can be controlled and cleaned up by the person responsible. The role of the provincial authorities in this and the previous case would be to ensure that the spill has been effectively dealt with.

Briefly then, it can be seen from the foregoing that a massive spill would come under federal command. A somewhat smaller spill not requiring a major use of federal resources

would come under provincial command. Yet smaller spills would come under the command within the framework of a local contingency plan. Only when the latter incidents cannot be controlled by the local forces, would the provincial plan come into effect. Recognizing this delineation with regard to the action taken on a spill incident, it becomes apparent that there be close coordination and compatibility in the contingency plans that are developed by the various levels of government. Therefore, close liaison is necessary between contingency plans at the local levels and the Province, between the Province and the Federal Government and internationally with the United States. Insofar as the success of the provincial plan requires the support of the local contingency groups, the OWRC is meeting regularly with all such groups to ensure that this compatibility with the provincial plan is achieved.

Local Contingency Plans

To be effective, contingency planning must begin at the "grass roots" level. Some type of contingency plan should be developed at every industry or other facility where petroleum products and other hazardous materials are stored or handled in bulk. Individual industries should also be cognizant of spill prevention measures to reduce the possibility of spills from occurring. To date, very few industries outside of the petroleum industry have given consideration to development of contingency plans to deal with spill situations. It is recognized however that most industries have emergency procedures for fire fighting and these to some extent can provide a mechanism to deal with spill incidents. These procedures should be extended to cope with spill situations. The petroleum industry, at its refineries and its bulk handling facilities have developed contingency plans for spills. At the larger plants, comprehensive plans have been developed and specialized equipment and materials for spill control and cleanup have been purchased. At the smaller plants, the plans are restricted to reporting procedures and a minimum of materials.

Many contingency plans have been and are being developed on a cooperative basis throughout the Province. Again, most of these involve the petroleum industry who have recognized the need to be prepared for emergency situations. Cooperative plans have been developed in the Hamilton

area under the leadership of the Hamilton Harbour Commissioners and involve the industries in Hamilton Bay and the surrounding area, oil company storage facilities, oil pipeline companies, the oil refineries on Western Lake Ontario and the City of Hamilton. This group has been very active and has purchased considerable equipment and other materials to cope with spill incidents. In the Sarnia area, the Lambton Industrial Society has been instrumental in the development of cooperative contingency measures to deal with the spills to the St. Clair River. Throughout the Province, the oil companies have developed cooperative arrangements between their respective marketing groups to deal with spill incidents resulting from transportation accidents or occurring at their bulk storage facilities. In the Kingston area, the oil companies and other industries are developing a contingency plan on a cooperative basis to deal primarily with spills of bunker fuel oil. Unlike the Hamilton Group where equipment is being purchased jointly and being maintained by the Harbour Commissioners, the individual industries in the Kingston Group are purchasing their own equipment in accordance to their respective need. The equipment will however, be available to other members of the group.

Other groups active in contingency planning either on an individual or cooperative basis are the petroleum pipeline companies, the oil and gas well drilling industry on Lake Erie and the St. Lawrence Seaway and industries in the Welland Canal area.

Use of Chemicals for Oil Spills

To this point, the question of the use of chemical dispersants for oil spills has not been mentioned. This is a matter which is the subject of considerable controversy whenever there is oil on the water. In brief, the OWRC's policy for chemical dispersants is they should not be used to clean up oil spills because of their potential adverse effects on the water environment. However, it is recognized that the emergency nature of some spills requires that some action be taken quickly and the use of chemical dispersants may be the only alternative. To assist persons on the use of chemical dispersants, the OWRC has developed some very general guidelines to ensure that all the pertinent facts are taken into consideration before a decision is made to use a dispersing chemical. These guidelines state that dispersants should not

in costs that must be borne by the person responsible. The policy of the Provincial Government is that the person responsible for the spill shall assume all costs of cleanup. Therefore, in order to establish the specific source of the contaminant, it is imperative that samples and other supporting information be obtained by those on the scene.

The important action on any spill, however, is to effect containment and cleanup of the spilled material as quickly as possible using the resources that are readily available. A decision can be made afterwards regarding the cost responsibilities. The need for quick deployment of the available resources to contain a spill can not be overemphasized, otherwise a minor spill incident can quickly erupt into a major incident requiring a massive response on the part of all concerned.

In summary, contingency planning in the Province of Ontario has resulted in the preparation of an interim contingency plan which will provide for an orderly response to a major spill incident. Moreover, every opportunity is being taken to ensure that the provincial plan will be compatible with individual industry plans and area or regional plans being developed throughout the Province and also the Federal and International Contingency Plans that have been prepared so that an escalated response to spill incidents can be taken depending on their magnitude and influence. However, much work still needs to be done, not only to make the plan more effective, but to familiarize responsible persons in government and industry with the many aspects of oil spill control, containment and cleanup. This will be achieved through the activities of the newly-formed Interdepartmental Task Force on Contingency Planning.

In conclusion, one can not overemphasize the need to prevent spills, for if there were no spills, then there would not be a need to be in a state of preparedness and the development of contingency plans would be in vain. This would seem to be a utopian aim but that is no reason that we should not strive for it.

be used where the principal concern is the protection of surface water supplies, fish spawning areas, fishing areas, beaches and water fowl nesting areas. They may be considered for use where a fire and safety hazard is present, when the floating oil presents an imminent hazard to local water fowl and for control and cleanup of small oil slicks, but then only after all possible methods for containment, control and removal of oil have been ruled out.

Where a high potential for oil spills exists, the first line of defence should always be a containment device and subsequent removal of the oil. Storage of chemical dispersants for emergency use is permitted but where possible, the OWRC should be consulted and present when they are used. It goes without saying that only those dispersants exhibiting the minimum toxicity should be used and persons wishing to stock-pile dispersing chemicals should insist upon toxicity information from the supplier. The OWRC Division of Research can provide some general information on the relative toxicity of some of the proprietory chemical dispersants on the market. However, it should be recognized that this is a rapidly expanding market in which new chemicals are being introduced on a regular basis and it is difficult to keep up-to-date on all chemicals available.

Other chemicals have been developed for the sinking of oil, gelling oil, herding oil, but in most cases, their application for use of oil spills is more limited. As is the policy for chemical dispersants, these other types of chemicals should not be used without prior consultation with the OWRC.

Equipment

The Provincial Government has not committed itself to the purchase of specialized equipment for the control and cleanup of oil spills. The equipment that would be utilized in the event the Province of Ontario Contingency Plan is implemented would come from the available private sources detailed in the inventory list. This is another reason to maintain compatibility with the local contingency plans.

Cleanup Costs

Each response to a spill incident involving the cleanup or removal of the contaminant from the water results

Acknowledgements

The author would like to acknowledge the contributions of his colleagues in the OWRC, in particular Mr. N. Vanderkooy, in the coordination of contingency planning activities in the Commission.

A.V. Kneese

"INCENTIVES AND ENVIRONMENTAL MANAGEMENT"

BY

ALLEN V. KNEESE,
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QUALITY OF THE ENVIRONMENT PROGRAM

RESOURCES FOR THE FUTURE, INC.,
WASHINGTON, D.C.

Introduction

Much neglected in the recent, often rather frantic, discussions of environmental problems is an effort to understand why our social and economic systems produce the results they do and how we can use understanding of them to produce more desirable ones. Illustration of the poverty of understanding in this area are the frequent calls for morality with respect to the environment (morality is clearly needed, but the problem is not primarily a matter of failing morals), amazement that the problem doesn't go away when federal subsidies are provided (federal subsidies may be needed to help catch up, but they don't do anything positive to change perverse incentive structures), and a search for technological fixes (technology can help as well as hurt, but it can't, alas, relieve us of our task to design an economic and political system which produces desirable results).

In this paper I will argue that our present environmental problems, at least in their environmental pollution aspects, are primarily a result of failures in our system of economic incentives. By incentives I mean the system of economic penalties and rewards within which the decisions of businessmen and consumers are made.

Beyond this we have failed to design political institutions which comport with the character of the environmental management problems we face. I will expand slightly on these matters in the next section and wind up by suggesting a strategy in one of our major problem areas, water pollution, which builds on the concepts developed. In developing this theme I will refer specifically to the situation in the United States. But I believe much of what I have to say has pertinence for the Canadian situation as well.

Common Property and Private Property

It has often been said that what we need is a new morality or a new ethic if we are to avoid despoiling the earth. This is really a call for a new set of values which lays more emphasis on the natural, the tranquil, the beautiful, and the very long run. These are values very appealing to me, as I'm sure they are to many of you, but holding them really says nothing about the social mechanisms through which they might be realized to a higher degree. Even "good" people need rules to live by, especially where the impact of a single person's behavior on the total problem is extremely small. Moreover, it has long been realized that a system which does not rely heavily on the fulfillment of the self-interest of the individual or the family must soon become undemocratic or unworkable.

In 1835 that remarkably acute man de Tocqueville said, "If you do not succeed in connecting the notion of right with that of personal interest, which is the only immutable point in the human heart, what means will you have of governing the world except by fear?"

The writers of the Federalist Papers and framers of the Constitution were very much aware of this point and by and large were successful in wedding de Tocqueville's two notions in their time. The social engine which they created was built largely on the concepts of private property and individual freedom within a framework of laws to keep the channels of commerce open. This reflected the conviction that private ownership, freedom of individual choice, and the profit motive would direct resources to those uses where they are most productive, given individual preferences for various goods and services and the income of the population. This conviction, plus fear of losing personal freedom, have underlain our national assumption that the role of collective action through government should be minimized and have been used to justify our traditional antipathy toward planning.

Of course, the need for a degree of collective action regarding the allocation and use of resources has been realized by almost everyone for a long time. Public works and defense have always had strong appeal. People recognized that a certain minimum amount of collective action was needed to realize gains from cooperation. Accordingly, we have used public funds to build roads and dams, and schools, and generally for those activities where economies of large scale dictated huge investments or where investments would yield widespread public gains, profits from which private enterprise could not capture and therefore would not provide.

With a few major exceptions, like the Great Depression, this mechanism has worked very effectively toward the rapid exploitation of our basic resources and a rapidly growing GNP. The levels of human welfare achieved by means of this mechanism should not be forgotten or downgraded as, unfortunately, they frequently are at the present time.

But now we have come to realize that there is another reason, and one of rapidly increasing importance, why the uncoordinated decisions of the individual, the household, the private firm, and even local units of government cannot be taken to lead to an overall desirable result. We call this additional reason for a faltering "invisible hand" the need to protect the quality of the environment.

A definition of environment or environmental quality which would suit everyone seems to be impossible. But I think that many concerned persons have something like the economist's image of "common property resources" in mind when they speak of the environment. The concept of a common property resource (which should not be confused with a similar legal terminology) encompasses those valuable attributes of the natural world which cannot be, or can be only imperfectly, reduced to individual ownership and therefore do not enter into the processes of market exchange and the price system. It should be noted that this concept is inherently a social rather than a natural science one but that the resources to which it relates are normally attributes of the natural world rather than the direct services of human beings. Notable among such resources are the air mantle, watercourses, complex ecological systems, and at least certain attributes of space. The last includes visual properties of landscape and the radio spectrum, among others.

The one main feature which all these common property (or in our context environmental) resources have in common is that they are subject to congestion. At some low level of use, an additional user of the resource may impose virtually no cost on others. However, a point is reached where an additional user will cause others to have to incur additional costs or suffer disutilities associated with congestion. When this stage is reached, what economists call an externality or spillover effect occurs. In other words, a particular user does not take account of the cost he imposes on others when he decides to use the common property resource. Many instances of this surround us--environmental pollution, mutual interference of radio signals, congestion on public roadways and in public recreation areas, jet plane noise, and scarred landscapes, among many others.

Our usual mechanism for limiting the use of resources and leading them into their highest productivity employments is the prices which are established in markets through exchanges between buyers and sellers. For common property resources this mechanism does not function, and they must become the focus for collective or public management, unless they are to be severely overused and misused. This idea has been well developed in the economics literature with respect to particular resources like ocean fisheries. However, how pervasive common property problems have become has not been widely appreciated by economists--at least not until recently. I have noted with interest that the ecologists have discovered the concept of the commons--it appears independently. The basic reference here is Garrett Hardin's Science magazine article "The Tragedy of the Commons" which has been widely quoted and discussed.

An Example--Residuals from Production and Consumption

It is now clear that the main basis for collective action in our society is shifting from the need for collective investment to realize widespread benefits to the urgent need to manage the rampant overuse and misuse of our common property resources. We can be fully confident that this need will continue to rise very strongly in the future. An example can help to illustrate this point.

It is one of the most elementary concepts of physics that matter is created or destroyed in only minute amounts. Thus it is clear that in the production and consumption activities of the society the material substances which flow from our natural resources are not destroyed on their way through the economic system but must in fact eventually return to the natural environment. As I indicated previously, our historic legal, economic, and governmental institutions were well designed to facilitate the process of extracting natural resources and guiding them efficiently to various uses in the economy. Thus, in general, our dependence on private property rights and the profit motive have served us well in developing our natural resources and converting them to useful goods. But what happens to the material substances after they go through this process and yield their utility to human beings? Clearly, these residuals have to return to one of the natural environments. It was fortunate for the smooth operation of our production and consumption system that the residuals-receiving capacity of our land, air, and water environments was sufficiently large relative to the demands put upon them that, except for some local situations, no serious results followed from the free and unhindered use of these common property resources.

Now, however, the natural reservoirs of assimilative capacity are rapidly filling up, becoming congested, and the individual waste disposer imposes important external costs on others by his activities. External costs are real social costs which are, however, not borne by the economic entity imposing them. They are therefore neglected and lead to misuse of resources.

It is clear that the return of waste residuals to our common property environments confronts us with a severe problem, because our normal property and exchange institutions for regulating and controlling the allocation and use of resources cannot function in these spheres. We are thus confronted with a large-scale--indeed pervasive--and unfamiliar problem of collective action and collective management.

This problem is complicated by the fact that the dispersal of residuals--materials and energy--to the environment usually involves entropy. This process of dilution is ordinarily beneficial as far as local effects are concerned in that it lowers concentrations in the neighborhood of the discharge, thus attenuating destructive effects. The other side of the coin is that it spreads the residuals over much larger areas. This has two important corollary effects from the point of view of environmental quality management: (1) it makes recovery and recycle of materials and energy much less economical, both in the short and in the long run, and (2) it means that the damaging effects of residuals are widespread in space, often extending beyond the geographical scope of existing governments of general jurisdiction. The effects of waterborne and airborne residuals extend across air- and watersheds which will seldom, if ever, correspond to the boundaries of existing government units. Depending upon the persistence of the substance involved and the means or propagation in the environment, the range of effects may extend from a comparatively few miles (heavy particulates in the atmosphere) to

large river systems (persistent organic chemicals) to the entire planet (CO_2 and radioactive fallout). Accordingly, society faces the need to pursue collective management efforts involving cooperation among existing units of government and the creation of completely new ones on a regional, national, and international scale with attendant severe problems of institutional conflict.

We urgently need to understand better how to build government institutions which comport better with contemporary problems.

To say we should not use the environment at all for residuals disposal, i.e., maintain a completely natural environment and suffer no man-made damages or risks is a simple and comfortable answer for some, and one which avoids all these difficulties. But this is, unfortunately, an utterly useless counsel of perfection. Conservationists and others sometimes argue that no burden should be placed on particular environmental media such as watercourses. It is even possible that such a goal could be reached in a limited situation without drastic reduction in the production of other things. But as a moment's reflection (keeping principles of mass and energy conservation in mind) will make clear, this must be an outlandishly impossible objective for all environmental media taken simultaneously. The conditions required for doing this would be even more exacting than those for a space ship, since even a spaceship could usually dissipate certain amounts of material and energy. It would be necessary to utilize only solar energy and hold all materials which could not be naturally recycled in closed-managed recycle. This is idealism run wild and very likely to be counterproductive to efforts to manage environmental problems in the real world.

Looking at matters this way also helps us to understand that there is very unlikely to be any spectacular technological "fix" which will allow us to escape the social problem of managing an environment which has been and will be profoundly modified by man's activities. What we must learn to do is <u>manage</u> our environmental resources. This will involve a combination of forbidding their use where adverse effects of any level of use are deemed to outweigh benefits (prohibition of DDT may be a good example), restricting their use through standards or, more desirably, explicit prices set by government, and where feasible improving the quality of the resource through carefully planned acts of public investment and operation of facilities. These tasks must be viewed as being an inherent part of economics and government in the contemporary world, tasks which must be performed continuously and indefinitely. This means that responsibility for their performance must be built systematically into our government structure and system of economic incentives. Needless to say this orientation is quite different from that which supposes that we can somehow go out and <u>solve</u> the problem completely in one decisive stroke. It doesn't make for very good drama because the emphasis is on persistence and strategy rather than acts of nobility or heroism, and "heavies" are largely missing from the cast.

Strategies for Water Quality Management in the United States

I would now like to turn, as a specific example, to an area where I believe that research has already laid a reasonably satisfactory groundwork for implementing the type of strategy outlined above. This is the area of water pollution control. In my opinion our present strategy in this area does not have an orientation which will lead toward effective, efficient, and continuing management of the problem. Much of what I will say is discussed in more detail in a book by Blair Bower and myself, called Managing Water Quality: Economics, Technology, Institutions (The Johns Hopkins Press, 1968). My discussion focuses on the situation in the United States, since that is the one with which I am most familiar. My impression is that Canada has done a better job of laying down a basic strategy for dealing with the problem.

To start with, I would like to characterize briefly what I take to be the present strategy of the federal government for achieving water pollution control in the United States. This strategy is based on two main elements. The first is financial support for municipal waste treatment plant construction. Such support started with the Federal Water Pollution Control Act of 1956 and has continued at higher levels of authorization since then. The 1966 Act authorized $3.4 billion for municipal sewage plant construction grants over the period 1968-71. Under the Act it is possible for municipalities to cover up to 55 percent of the costs of waste treatment plant construction from federal grants.

The second element in our pollution control strategy was instituted by the Water Pollution Control Act of 1965 which required that all states set water quality standards on their interstate and boundary waters. These standards were to be completed and reviewed by the Secretary of the Interior by mid-1967. Understandably enough, there were some delays but the required standards are now for the most part in existence. The standards were to be accompanied by a proposed program for achieving them which could then be used as a benchmark against which to judge the need for federal enforcement actions. Actually, while the federal government has had authority to bring enforcement proceedings against interstate polluters in the past, this program has been used only to a very limited extent.

Without in any way denigrating the great and sustained efforts made by Senator Muskie and others to provide us with effective pollution control legislation, I think it is fair to say that the results of our pollution control strategy up to this point have been disappointing to many. Municipal treatment plant construction has been lagging partly because federal appropriations for treatment plant construction have fallen far behind authorizations, and many people assert that municipalities are holding up construction until federal funds become available. Federal enforcement powers have not been very effective, in part because of the difficulty and cost of mounting effective enforcement proceedings and the political power of the larger industries. For documentation on the way federal enforcement has been conducted, see the report by Ralph Nader's Task Force on Water Pollution, called "Water Wasteland" (Center for Study

of Responsive Law, Washington, D.C., 1971).

Another recent report, this one by a government agency, the General Accounting Office, entitled "Examination into the Effectiveness of the Construction Program for Abating, Controlling, and Preventing Water Pollution" (The Comptroller General of the United States, Nov. 3, 1969), has provided a rather devastating critique of the present strategy based primarily on the scattershot way in which support has been provided municipal treatment plants, the poor operation of existing plants, and the overwhelming growth of industrial waste water discharges. In every major river system studied by the GAO, the conclusion was the same: we have failed to mount a significant attack against the major contributors of pollution. Relying exclusively on the tool of enforcement, especially in view of the time-consuming and cumbersome procedures built into the present process, to remedy this situation would, I am sure, be awkward, unpleasant, expensive, and effective at best only in a static and short-run sense.

As part of our subsidy-enforcement strategy, many bills have been introduced in Congress to provide federal subsidies for the construction of industrial waste treatment plants. These proposals have for the most part so far not been successful. From the point of view of trying to achieve an efficient as well as an effective pollution control policy, this may be regarded as fortunate. For reasons that I hope will become clear from my further discussion, subsidies for industrial waste treatment would tend to be less efficient than incentives to adopt other waste reduction procedures, such as recycle and by-product recovery. Moreover, they would have the unfortunate effect of diminishing the extent to which costs of using the common property resource are reflected in the goods which consumers buy, thus leading to too much consumption of them relative to their social cost of production. In addition to efficiency considerations, many people also regard it as just or equitable that those industries and consumers who use common property resources to the detriment of others bear the cost of doing so.

Unfortunately, a certain amount of subsidy has already crept into the system. Some industrial plants are connected to municipal systems and can benefit from the subsidies to municipal treatment plant construction. Furthermore, the last tax reform bill passed by Congress provides for 5-year tax amortization of pollution control facilities. In addition to the points already made about the inefficiencies of subsidies, a weakness of rapid tax amortization is that it cannot help those marginal firms which often serve as the excuse for subsidy arrangements. Tax write-offs would seem to be a particularly perverse way to try to deal with the situation. They have the effect of providing most assistance where it is not particularly needed and, unless counteracted by other provisions, letting the industrial plant where assistance might be justified die. Subsidies of course do have the politically attractive feature of spreading burdens so widely that no individual has an incentive to scream very loud. If they can be hidden behind the complexities of the tax system, it's even better. When Charles Schultze was Director of the Bureau of the Budget, he used a sign hanging in his

office which said, "If you can't solve the problem, subsidize it." There is an unfortunate amount of truth in this.

Several years ago, I proposed an alternative strategy for dealing with our national water pollution problems which, I think, now has the support of most of the professional economists who have studied the matter. I believe if this strategy had been adopted, our efforts to improve the quality of our national waters would be substantially further advanced than they are, and we would be moving into a position to achieve justifiable or desirable levels of water quality at the least cost to society. To quote a famous Washington personage who lives on Pennsylvania Avenue, "I want to make one thing perfectly clear." This strategy is not a product of the abstract musings of a few ivory-tower economists, as some who wish to delude people about it would have us believe. Rather it results from careful reasoning about the private enterprise system by scholars who are generally sympathetic to it and from hard and careful quantitative research.

This proposed alternative strategy is also based on two elements. The first rests on the concept that the waste discharger should insofar as possible bear the damages his waste disposal activities impose on the common property resources of society. The second recognizes that in many of our highly developed basins, where pollution problems are concentrated, great savings in costs can be obtained by the implementation of a systematic and well-integrated water quality management plan on a regional basis. The latter would contain elements other than just the treatment of waste waters at particular outfalls.

I would like to elaborate briefly on these points and suggest some ways in which the federal government might contribute to the development of the sort of strategy I have in mind. With respect to the first element, I think we must devise ways of reflecting the costs of using resources that are the common property of everyone, like our watercourses, directly in the decision-making of industries, local government, and consumers. The waste assimilative capacity of our rivers is a valuable asset, and these rivers have alternative uses with which waste disposal conflicts directly. As I indicated earlier, because our property institutions cannot adequately be applied to resources like watercourses, they are essentially unpriced and treated as free goods, even though they are in fact resources of great and increasing value in the contemporary world. It seems to me that this unhappy situation cannot be remedied unless we move toward the implementation of publicly administered prices for waste discharge to watercourses and for the use of other common property resources.

Accordingly, one element of my proposed strategy for water quality management is a system of what I have termed "effluent charges". The proceeds from such charges would yield a rent on a scarce resource to society which could be used in various ways, including further measures to improve water quality, as discussed below. Also, and even more important, the effluent charge would provide an incentive to conserve in the use of the watercourses for waste discharge. Detailed industry studies have shown that

industries can often reduce waste discharges enormously, usually at low cost, if they are given a proper incentive to do so (see, for example, George Löf and Allen Kneese, The Economics of Water Utilization in the Beet Sugar Industry [The Johns Hopkins Press, 1968]). In many instances, the most effective means for reducing waste discharges is internal process change and recovery and recycle of materials that would otherwise be lost.

Similarly, under our present property institutions, municipalities are paying only part of the social costs of disposing waste to streams, and what they pay is rather capriciously distributed depending on how much waste water treatment they have implemented. Just how capricious this is is well documented in the most recent Cost of Clean Water report from the Environmental Protection Agency as well as by the GAO Report mentioned earlier. The effluent charges system would give municipalities an incentive to proceed expeditiously in the treatment of waste. Another point of some importance is that our present policies put heavy emphasis on the construction of plants with little or no follow-through on operations. Experts have pointed out that many treatment plants are operated far below their capabilities. That this situation exists has recently been documented in another GAO report. The effluent charges system focuses on what is put in the stream and thereby offers an incentive for effective operations of existing facilities.

It should be clearly recognized that the present and proposed subsidy arrangements are quite different and, most economists would feel, less desirable in their impacts than the effluent charges system.

First, the system of effluent charges is based on the concept that efficiency and equity require payment for the use of valuable resources whether they happen to be privately or collectively owned. These prices will be reflected in the industrial producers' decision to install treatment equipment and otherwise reduce the generations of residuals. They will also be reflected in the price of intermediate and final goods, so that a broader incentive will be provided to shift to goods with a lesser environmental cost.

Second, subsidies for treatment plant construction do not, by themselves, provide an incentive to take action to control waste discharges. Even if an industry or a municipality is paid a major proportion of the cost of waste treatment plant construction, it is still cheaper, from the point of view of the industry, to dump untreated waste into the river. Thus, the subsidy arrangement cannot work unless accompanied by enforcement or other pressures on the waste discharger. That this connection has not been made in practice is richly illustrated by the GAO and Nader Reports already mentioned.

Third, to the extent that the subsidy system works it tends to bias the choice of techniques in an inefficient direction. It would provide an incentive to construct treatment plants with federal subsidy, even though internal controls would be cheaper.

Finally, the effluent charges system yields revenue rather than further straining an already seriously overextended general tax

system. This revenue can be put to useful public purposes including improvements in the quality of our environment. From an economic point of view, perhaps the best imaginable tax base is an activity that causes external diseconomies. Not only does a tax on such a base yield revenue but it tends to improve the overall allocation of resources.

There seem to me to be compelling reasons for favoring the effluent charges system as one of the cornerstones of effective and efficient regional water quality management. But it may be difficult for particular states and regions to pioneer such a substantial departure from previous practice. The federal government's greater insulation from powerful local interests provide an opportunity for leadership. One approach would be for the federal government to levy a national effluent charge on all waste dischargers above some minimum amount. The charge could be based on a formula similar to those that are used in the Ruhr area of West Germany or one of those used by certain U.S. municipalities in levying sewer service charges upon industry. This charge could be considered a minimum which could at their discretion be exceeded by a state or regional agency having responsibility for water quality management. The level of the national charge would necessarily be somewhat arbitrary, but it would be possible to select a level which would result in a substantial incentive to reduce waste discharges--which has been stated as a national goal in our legislation. Revenues obtained by the federal government could be made available for purposes of financing the federal program with the excess turned over to other governments of general jurisdiction or, and I think preferably, the revenues could be used to establish regional water quality management agencies which are the other element in my proposed strategy. Of course, revenues obtained would tend to decline rapidly as waste discharges are controlled.

Research on water quality management over the past several years has clearly shown that major efficiencies can be obtained by the implementation of water quality management systems on a regional basis. Some of the evidence on this is presented in the book Managing Water Quality mentioned earlier, but further evidence continues to accumulate.

In addition to the standard treatment of waste waters, such management systems could include a number of other alternatives closely articulated in planning and operation. These could include riverflow regulation, putting air directly into streams, brief periods of high-level chemical treatment during adverse conditions, and others. Studies of the Potomac, the Miami of Ohio, the Delaware, and of other areas have shown beyond question the economies to be realized by this kind of regional approach. It appears that such an approach can only be effectively implemented by a regional river basin agency having the authority to plan, construct, and operate the necessary facilities. Again, there is a role for federal leadership in the establishments of such agencies. So far, tendencies to support such an approach at the federal level have been minimal.

The federal government could, of course, take direct action. It could set up regional water quality management agencies or

regional water resource management agencies. These could be separate entities, such as TVA, or regional units of federal agencies, such as proposed by the first Hoover Commission. There has been so much opposition to arrangements of this nature that it is questionable whether the federal government should or would be willing to move in this fashion. An alternative would be for the federal government to establish incentives and guidelines for the organization and operation of regional management agencies, either under state law or through interstate compacts. An agency with adequate authority to plan and implement a regional water quality management system would be eligible for a grant of funds to support a portion of its budget to help staff the agency and to make the first data collections, analyses, and formulation of specific measures for water quality management. If the federal government is satisfied that the proposed program and the plan for its implementation satisfy criteria for its efficient operation, the agency might be eligible for a grant to assist it with actual construction and operating expenses. Such a system might appropriately be limited to the early implementation--say, five years. During this period, it would be necessary to work out longer-term arrangements for financing the agency. Clearly, the proposed effluent charges system could play a major role in this. Presumably, administration of the effluent charges system would be turned over to the regional agencies with the federal level of charges continuing to be regarded as a baseline. In this manner, regional scale measures would be financed while at the same time providing appropriate incentives to waste dischargers to cut back on their emissions. Special provisions might be included in the federal law toward marginal industrial plants which might go under and where there is a broader social interest in protecting them. It should be noted that where serious efforts to implement regional water quality management have been undertaken (as in the Delaware and the Miami), one of the most serious problems has been to set up adequate financing arrangements.

I have no doubt that federal leadership toward implementation of an effluent charges system and the creation of regional water quality management agencies could put the United States on the path to continuing effective and efficient management of the quality of its common property water resources.

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"IMPROVED WASTE CONTROL IN THE PLATING AND RELATED INDUSTRIES THROUGH IN-PLANT CONTROLS, WATER RE-USE AND WASTE RECLAMATION"

BY

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The plating industry is a major source of effluent contamination because of its use of concentrated metal bearing electrolytes, cyanides, alkaline cleaners and acids. These show up in the effluent stream as a result of running rinses, floor spills, leaks and deliberate dumps.

The metals most frequently encountered are chromium, nickel, copper, zinc, cadmium, tin, silver, gold, a small amount of palladium and other rarer metals. Aluminum and iron are not usually a problem. Many plating plants, because of the balance of acid and alkali running rinses, stay within the pH limits required from this source but will exceed these limits when dumping spent

cleaners or acids. Similarly, suspended solids will usually meet sanitary sewer requirements but will not meet storm sewer standards.

All platers must take some action in order to meet all requirements at all times. Many have, but more will yet be required to come up to standard.

The industry is not very strong economically at this time and some quite large operations have been discontinued within the last year and a half. This condition has not helped the financing of pollution control and has prompted some companies to make baling wire approaches to their problem. These have often not been successful.

For the most part, the industry takes a responsible attitude to the problems and genuinely wants to do something about it. Unfortunately, many of them lack the human resources to study and prepare the best approach.

It is obvious to most that the best approach is to retain materials in their appropriate tanks. This is not always easy to do and involves changing procedures in practice for many years. The suppliers to the industry have done much to show the way and there is much in the literature as support.

As part of this paper, I should like to illustrate once again what can be accomplished by in-plant controls.

The installation at Webster Manufacturing (London) Limited was the first in Canada designed specifically with pollution control in mind. This plant plates automotive hardware with copper nickel and chrome and includes the preplate cleaning system. The solutions used are copper cyanide, nickel sulphate, chromic acid, alkaline cleaners and 5% sulphuric acid.

This machine, a programmed hoist system, was ordered in 1967 and went into service in November, 1968. A table of typical results in effluent sampling is shown in Table 1.

Provision was made for underground treatment of all wastes should it become necessary. In addition to the results shown in the Table, there has been one finding of low pH and one of chromium at 8 ppm in the two and a half years of operation. The chromium will tend to build up over a period of time and it is now a procedure to dump the first rinse after chromium every four months and batch

treat it. This plant is well run and maintained and care to prevent leaks has avoided trouble from this source. The construction of the machine virtually eliminates floor spills. Filter dumps are avoided by backwash procedures that recover the solution and other necessary dumps of cleaners and weak acids are handled by procedures that distribute the load over a period of time.

The programming of the machine permits control of rinsing and draining so that retention is maximised within the limits of the process and the procedure is reproduced every cycle.

While we cannot quite meet the requirements for storm sewer or stream, design and in-plant procedures will drastically cut capital and operating cost of waste treatment.

These principles apply to any plating operation and are capable of being carried out in some degree in all plants.

However, when the best possible circumstances for retention have been achieved, there are still many applications which have excessive quantities of metal or cyanide in their effluents and the wise company looks to the possibility of recovering its losses.

As with treatment systems in general, there are many approaches open and it is difficult to assess properly the best approach. There are not usually enough installations in existence to give a clear picture of the relative advantages.

For water recovery alone there are evaporative, ion exchange and precipitation methods for removing contaminants and returning all or some of the water to the system.

The evaporative approach I will deal with in conjunction with metal recovery.

Ion exchange is an obvious way to recover high purity water and amongst the claims for advantage in using this method is better rinsing between plating stages.

This latter is somewhat in dispute but, nevertheless, when there are severe restrictions on how much water may be discharged to sewers it can become practical.

An example of this application is at British Motor Car in Oxford, England. This plant is in a built-up residential area of

Oxford and the municipal sewer cannot handle any more load. The installation was made a few years ago with duplicated combined anion-cation towers preceded by filters. This proved completely unsatisfactory because before all metals were removed by the cation resins, hydroxides formed and these blinded the resin beds The system was then split into separate anion and cation towers but there was still some bleed-through of metals to the anion tower and some cation resin was inserted in the anion tower.

The de-ionised water was at first returned directly to the plating rinses but since many of the rinse tanks were mild steel, it was necessary to add caustic to raise the pH.

Apart from these difficulties, ion exchange installations have a high capital cost and resin life, while improving, is still an expensive operating cost. There is still a backwash of chemicals to be coped with but it is one-tenth the original volume and may sometimes be batch treated or even recovered.

Water recovery is also possible from continuous effluent treatment systems which use chemical dosage to precipitate or destroy contaminants. The ability to reuse water from this source is somewhat dependent on the process but one that is successful is in Redditch, England, where 80% of the rinse waters are returned to the plating plant.

This installation is plating cadmium on steel and this is followed by a chromate dipping operation. The cyanide from the cadmium plating rinses is destroyed continuously and the cadmium and chromium are precipitated separately and the hydroxide sludge settled in silo-shaped clarifiers. 80% of the overflow from the top of the clarifiers is returned to the respective rinsing systems. Some make-up water is added to prevent a harmful build-up of ions from the dosing chemicals. A similar recovery will shortly be in operation at EMCO Limited in London, Ontario.

Metal recovery is somewhat more complicated and the resultant product not so readily used. Chemical recovery of metal in the mining industry is well established but the same procedures do not work out so well in the plating industry because of the low concentrations encountered. Chemical recovery of the cheaper [illegible] simply is not justified but, beginning with copper, there is some promise.

Copper plating from copper sulphate baths is most common in plating on steel or plastics and has had increased usage in recent years. From these baths copper may be recovered from the rinsing cycle by rinsing in a chemical wash containing caustic soda, soda ash and a reducing agent. The sludge generated is nearly 50% solids and of that, 50% is copper oxide. This has been accomplished in Germany and I believe in the United States but there are no installations in Canada. Copper precipitated as the hydroxide and filtered to a cake finds a market in some places.

In Birmingham, England, the entire cost of operating a treatment plant in a copper pickling operation is recovered by selling a filtered cake of copper hydroxide. There are similar applications in the United States but there appear to be none here. Nickel hydroxide sludge similarly seems to be of little interest but nickel carbonate has some possibilities. Again in England, at the Raleigh Bicycle plant in Nottingham, nickel carbonate is precipitated in a chemical wash which follows nickel plating. The flow chart of this operation is shown in Figure 1.

The chemical wash is soda ash and the caustic soda continuously circulated to a reservoir and settling tank. pH is controlled by meter but soda ash is added at a predetermined rate. The resulting sludge is periodically removed and filtered in an automatic filter which washes the cake to remove sodium and then backwashes to a holding tank containing sulphuric acid, thus regenerating nickel sulphate. The nickel sulphate is then added back directly to the plating tank.

This process is also used in Canada without the filtering and regeneration stage and the resultant sludge is sold. A sludge thickening procedure produces a sludge of 5% nickel along with sulphate and alkalis. The system designers claim a possible 8% nickel content. These gaps between performance and design seem inherent in most systems.

Chrome recovery by chemical means has not proven practical, again because of a lack of market.

In a related field some special processes have been developed to recover copper chemically.

One of these is at Northern Electric in Belleville, Ontario. This plant which makes printed circuit boards, dissolves about 80 lbs. of copper a day and this poses a considerable problem of disposal as the hydroxide in standard chemical methods.

Chemicals used for dissolving copper in circuit board work include ferric chloride, chromic acid and ammonium persulphate. At Belleville they had been using ferric chloride in a batch process and have now replaced it with a system of dissolving and recovery using ammonium persulphate with mercuric chloride as a catalyst. This process, which is removing copper as the copper ammonium sulphate at frequent intervals, is shown schematically as Figure #2.

The reaction products are crystallized at 40°F. The resulting crystals are filtered as a damp copper-bearing salt and the filtrate is re-fortified by the addition of solid ammonium persulphate.

The recovered copper salt is marketable right in Belleville where it is sold to a manufacturer of wood preservatives who makes copper napthanate. The price is 2 cents per pound for the filtered sludge. The dollar recovery about equals the cost of precipitation and disposal by standard process.

Troubles have involved pumps -- everyone's problem when moving corrosive chemicals -- and the centrifugal filter has proven to have considerable tendency to leak. The entire installation, which includes etching process itself, cost about $50,000.

Electrolytic recovery of copper has been in practice in the copper and brass pickling field for a few years now and an installation in New Jersey partly financed by a U.S. Government Demonstration Grant is operating at a slight gain in operating cost as against a large operating loss for standard chemical destruction procedures.

Another similar grant has been made to the same engineering company and a plating plant in Grand Rapids, Michigan, for the electrolytic recovery of nickel.

Electrolytic recovery is ideal where the metal load is heavy and there is only one metal or at least where the other metals present are in low concentration and do not plate out at the same current densities as the main metal. However, when the concentration is below 300 ppm, it generally requires too high voltages of D.C. power to be economical.

An English engineering company, again with government assistance, is at advanced development stage of a process which will start at 300 ppm copper in copper sulphate and remove copper to the level of 10 ppm in 25 minutes. The principle involves the use of

very large cathode areas and requires only standard low voltage rectifiers used in the plating industry. The cathode is a suspension of copper particles held there by the flow of copper solution, electrified by a grid. The particles starting at about 400 micron size are allowed to grow to about 1200 microns at which point they settle and are drawn off. Further details are due to be published shortly.

Electrodialysis has reached commercial stages and equipment will be marketed later in the year for plating applications. This combination of osmotic effects and electrolysis has been in use on a large prototype basis at RCA in Camden, N.J. where printed circuits are etched with chromic acid. Copper is recovered as powdered copper and chromic acid is regenerated. I have not been able to obtain any figures to develop the economic justification or life of this equipment.

The developers of the equipment are expecting to find a market not only in this field but in the purification of chromic acid used in plating and in the preplate etch used in plating plastics. In the former, metals and trivalent chromium build-up can lead to dumps and in the latter, trivalent chromium build-up causes frequent dumping. Cost of these units will probably be in the $20,000 range.

Turning now to evaporative techniques, we have one of the oldest recovery approaches in the industry. That is to concentrate the rinse to something near the bath concentration and re-use it. The industry turned first to chromium recovery by this method because the low temperature at which the baths operate does not permit the return of much dragged-out solution to the plating bath as replacement for bath evaporation.

There are few of these installations in Canada and a new one just being installed has two closed loop systems for the recovery of both chromium and nickel solutions. In these, the recovered condensate is returned to the rinsing system and the concentrated solution to the plating bath on a continuous basis.

I have been critical of some specific applications of this approach and still am because there is a tendency to over-predict the recovery and to under-predict the operating costs and problems.

Over-prediction of recovery is often based on using high loss figures which could have been drastically reduced by techniques such as used in my first illustration at Webster. Secondly, not all losses are in the rinsing stream, especially where nickel and metal cyanide plating is involved.

I have chosen to look a little more closely at an installation that had examined the possibilities of retention and proceeded as far as they could in this direction and then elected to install an evaporative system for the recovery of nickel.

Houdaille Industries in Oshawa, Ontario, is the largest plater of automotive bumpers in Canada and has the largest nickel plating tanks. They had had an evaporative recovery system on their chrome for some years and decided to buy only the evaporator and its ancillary equipment from the manufacturer and to do their own engineering and control installation.

The nickel rinse system, which is all I will deal with, has a rinse flow of 250 gph. The evaporator is designed to evaporate 220 gph. The difference is made up with fresh water. It is essential that there be at least three counter flowing rinses after the plating operation for the success of an evaporative system. At Houdaille, they have four.

It is a vacuum evaporator operating at 140^{o}F, thus permitting the use of plastic materials in much of the installation. Nickel in the rinses was 25 ppm in 50,000 gph of total plant effluent and is now 1.0 ppm in 25,000 gph and will reach 0.5 ppm when the evaporator is fully operational. The dragout rate is approximately 15 gallons per hour of a solution containing 12 oz./ gallon nickel sulphate.

The cost to date for controls, installation and evaporator has been $60,000 against about $120,000 for the complete installation by the designer of the equipment. Some experimentation is still necessary before becoming fully effective. At this time, it will be recovering 50% of the total nickel losses. The remainder, made up of pump leaks, filter backwash and floor spills, is collected, evaporated in a simple still and returned to the plating system after purification and filtering.

This installation is not fully automatic since it is such a simple manual operation to add solution back to the plating tank as required, thus avoiding the complication of controls.

The return on investment will be in about three years and very little labour is required. The operation has been absorbed by existing staff. I have not gone into the details of the costs of operation of these systems since much of it is available in the literature but, as a general rule, the justification for such an installation occurs when the rinse waters contain 200 ppm or more of metal contaminant.

This company also has an arrangement that illustrates my final recovery system. They have frequent dumps of acid from the plating system of 5 - 10% concentration and heavy dumps from their pickling line containing large amounts of iron as ferrous sulphate. Across the road is a tannery which has large amounts of lime and sodium sulphide to dispose of. The latter in a sewage treatment plant can produce hydrogen sulphide. Partly by accident and partly because the tannery people were looking for a source of pickling waste, the two companies got together and have built a pipeline between the plants. The weak acid neutralizes the lime and the pickling waste reduces the sodium sulphide.

How many more opportunities are there in Canada for this sort of cooperation? I don't know and I don't believe anybody does. If left to accident, it will take a long time for these possibilities to match up. Similarly, the chance for metal recovery which is practical now in only a few facilities with frequent necessity to make dumps could be greatly increased if several smaller operations could get together. In England, commercial operations now exist in Birmingham to buy concentrated dumps containing metal for the purpose of recovering the metal.

Such developments in Canada may be practical today or will become so when the large cities begin to enforce their by-laws limiting metal concentrations in effluents.

It would seem a logical time for a government agency to set up a clearing house for information as to who has a dumping problem that might match up with someone else; or which might have a recovery value when added to someone else's.

However, this is not likely to happen for several reasons, which might be covered in discussion. Similarly, an independent organization such as the Canadian Institute for Pollution Control might undertake this service, but I don't expect they will at this time either.

In the absence of such service and on an experimental basis, I would be willing to act as such a clearing house. If anyone in Canada has reasonably concentrated dumps of inorganic solutions containing metals or inorganic acids or alkalis and wish to record the size, concentration and frequency with me, I will, without charge, keep a file and will endeavour to make each aware of the other.

Obviously, this will take some time to build up and response would not be immediate. If there is no response, then it would be a logical assumption that the need for such a service does not exist. I would not guarantee results and would not be responsible for any arrangement that might be set up, but I would like to speed up the spread of this information.

TABLE 1

WASTE DISPOSAL--WEBSTER MANUFACTURING, LONDON, ONTARIO

	HEXAVALENT CHROMIUM	CYANIDE	pH	COPPER
MARCH 31/70	3.2 PPM	3.2 PPM	7.9	1.01 PPM
APRIL 1/70	1.0 PPM	1.0 PPM	7.1	0.4 PPM
APRIL 7/70	1.2 PPM	3.0 PPM	8.6	0.4 PPM
APRIL 9/70	0.5 PPM	2.0 PPM	9.3	1.10 PPM
APRIL 15/70	0.85PPM	3.0 PPM	8.4	0.6 PPM
APRIL 17/70	0.46PPM	-	-	-
MAY 20/70	0.7 PPM	1.2 PPM	-	0.76 PPM
MAY 25/70	0.4 PPM	0.80PPM	8.1	1.2 PPM
MAY 27/70	0.34PPM	0.71PPM	8.1	9.52 PPM
JUNE 1/70	0.55PPM	1.1 PPM	8.3	1.0 PPM
JUNE 8/70	0.3 PPM	1.4 PPM	9.0	0.95 PPM

FIGURE 1

FLOW CHART OF

NICKEL RECOVERY FROM ELECTROPLATING

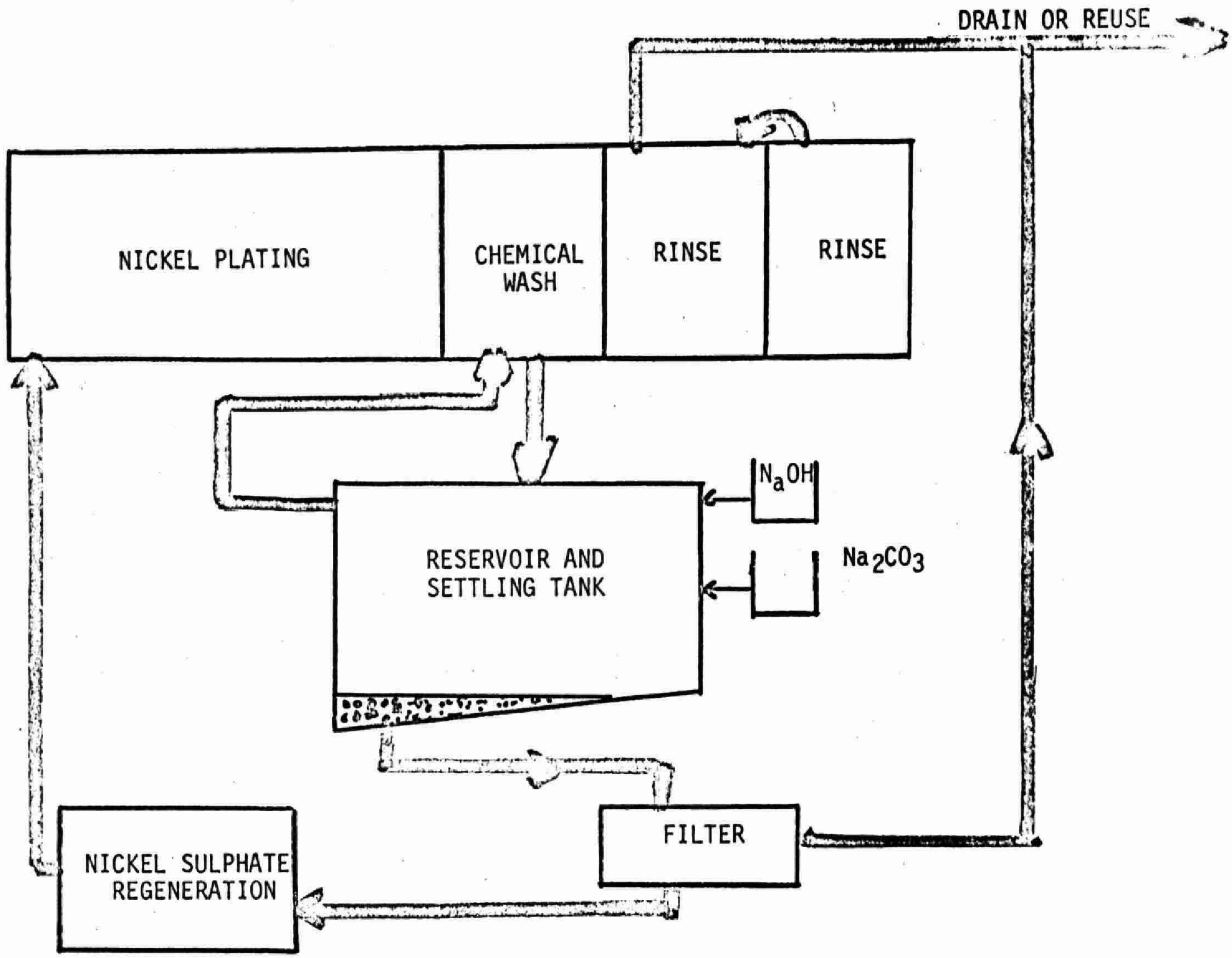
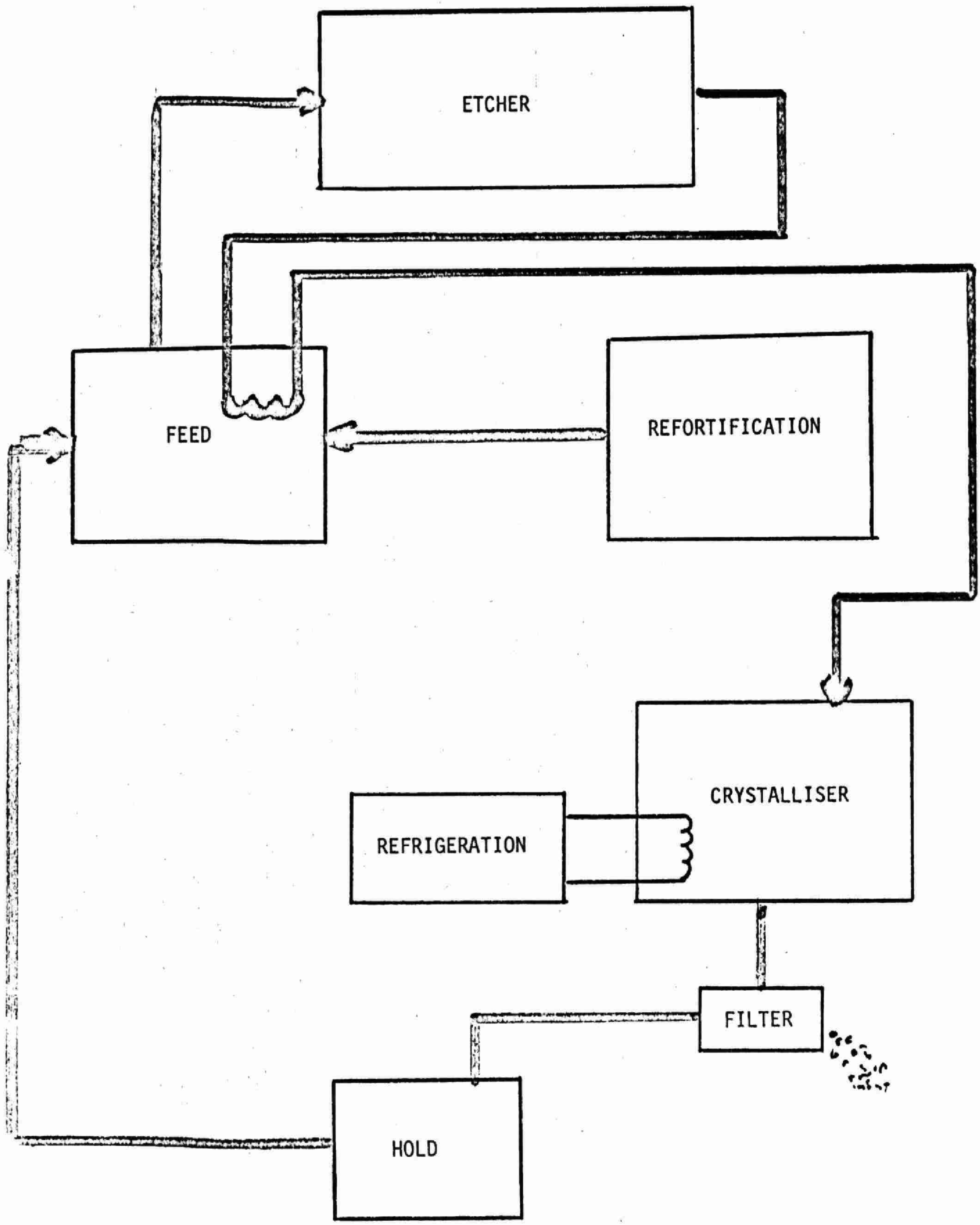


FIGURE 2

CAPER PROCESS FLOW CHART

$$(NH_4)_2S_2O_8 + Cu \longrightarrow CuSO_4 + (NH_4)_2SO_4$$



"WATER MANAGEMENT AND CONTROL IN A COPPER ROD MILL"

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BY

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It was interesting to note while looking through the records that Phillips Cables Limited, or Phillips Electrical Company as we were known in those days, had been working on, and spending money on, pollution abatement long before this word became the battlecry or the household word that it is today.

Even before the Ontario Water Resources Commission itself came into being, Phillips were taking action to reduce pollution to a minimum. The O.W.R.C. was created, I believe, in 1956, taking over the supervisory jurisdiction vested in the Ontario Department of Health. Two years before this, Phillips installed a huge waste water treatment system to remove copper scale from its Rod Mill effluent to the Brockville sewer system.

A schematic layout of the original plant is shown in Figure 1.

The sole purpose of a rod mill is to change the shape of metal as it is received, into something more readily used. Copper can be supplied in a variety of shapes from the smelter or refinery, such as ingots, billets, slabs, or, as we get it, in bars. These bars, called wire bars, are about 4" square and about $4\frac{1}{2}$ feet long. To get them into a usable shape from which to make wire, we first heat them and then pass them between a series of grooved rolls, reducing the size to about $\frac{1}{4}$".

Due to the high temperature, copper oxide forms readily on the surface. This copper oxide or scale must be removed and to do this we use water, which does a number of things - it helps to break up the scale by thermal shock, it flushes away the particles by mechanical action, and it also cools the rolls.

It is this water that is the villain in the piece - what to do with it, how to recover the valuable scale, and how to get rid of it without polluting the sewers.

Much of this scale is collected in scale pits and settling chambers equipped with baffles and built into the mill foundation. These are fairly effective but far from perfect.

As I recall it, there was little or no outside pressure to improve conditions. We, ourselves, felt that we were not doing quite the right thing. I do not want to imply that this was an altogether altruistic effort. If there had been no hope of recompense from the salvaged copper it might have been another story. However, regardless of the motives, we went ahead with the expenditure of some $50,000, exclusive of engineering costs, and with the additional bother and risk of disrupting production, and the installation was made as shown in Figure 2.

The volume of this settling tank was in excess of 100,00 gallons and we achieved the following:-

1. Discolouration of Butler's Creek with copper scale was significantly reduced.
2. Valuable copper was recovered.

Overloading of the Brockville sewer lines was relieved.

Over the years previous to this the sewer lines had become overloaded due to the natural growth of the town - more homes, more roads, etc. Recirculation of the water in the plant resulted in about a 90% reduction in the plant effluent and thus the overloading problem became less critical. As a matter of fact, it is only this year - almost 20 years later - that the City Council have had to consider the appropriation of funds for sewer improvement in this area of the city.

I said "Discolouration of Butler's Creek with copper scale was significantly reduced". This is about the truth. Discolouration was reduced but not eliminated, so efforts to reduce the concentration of copper in the effluent still further continued through the years and, in 1967, a major modification to the system was made as shown in Figure 3.

Butler's Creek, by the way, is a small stream flowing through our section of the city and emptying into the St. Lawrence River. It is in full view of everyone and by this time public interest had grown and the need for improvement was becoming more important.

The process water recirculates within the rod mill at a flow rate of approximately 1,100 g.p.m. The fresh water is used only as a lubricant for certain phenolic bearings in the mill and is the only excess water in the system outside of make-up. The main flow is recirculated back to the mill and the 100 g.p.m. equivalent to the bearing water is run through the settling tank, with a retention time of some 18 hours, and hence to the drain. We had high hopes for this and indeed, for a few days, results were excellent.

Then the quality of the effluent began to deteriorate slowly but surely. What was happening was that the small particles of scale that didn't settle were being recirculated and the mill was acting as a grinding mill, making the particles still smaller until they would float right through the settling tank. A sort of equilibrium was reached in which conditions were not much better than they had been before.

The properties of these particles were such that settling for 3 or 4 days, such as over a long weekend, had little effect. Although copper in solid form is not harmful in itself, discolouration caused by the fine particles acting as a pigment is

detrimental from an aesthetic point of view. Analysis of the feed and effluent from the settling tank showed the concentration of copper as in Figure 4.

Many experiments were performed to try to remove the very last traces of this material and finally the problem was solved by the Ontario Research Foundation. The effluent is now clear water with the copper content below the acceptable limit of 1 p.p.m.

With the concentration of copper up to 80 - 100 p.p.m. and a flow of 100 g.p.m. or 6,000 g.p.h. for an 8 or 10 hour working day, there was a significant loss of valuable metal as well as the noticeable contamination of the Creek. Although it was possible to dilute the effluent to below the 1 p.p.m. limit, this would not have reduced the quantity of copper wasted.

The objectives for the new treatment were specified as follows:-

1. Concentration of copper in the effluent below 1 p.p.m.
2. Further reduction of the contamination in Butler's Creek.
3. Recovery of the copper as a by-product.
4. Re-use of the clarified effluent as a lubricant.

Analysis of samples transported from Brockville to Sheridan Park revealed that the copper, as we had supposed, was in suspension, with the particle size varying from about 1/10 micron to 2 microns in size, and the pH was 8. Considering these properties, and the availability of the old facilities - settling tank, pump, sump, etc., the selected treatment was: coagulation, flocculation and sedimentation.

Experimental studies at the Ontario Research Foundation revealed the effect of different coagulants and polyelectrolytes on coagulation of colloidal copper.

In these tests the common jar test technique was used. Samples were prepared in calibrated 1,000 m.l. glass cylinders and the settling of the flocs. was recorded on film.

In this procedure the contents of the cylinders were rapidly mixed at 150 r.p.m. until the coagulant was dissolved (if added as a powder), or for 1 minute if added in solution. Polyelectrolyte was then added to the suspension and again mixed rapidly at the same speed for 1 minute. This was followed by 3-minute mixing at a slower speed - 90 r.p.m. - to allow the formation of aglomerates.

Immediately after mixing, photographs were taken at preset time intervals. For more accurate evaluation of samples, two additional cylinders were photographed, one with untreated waste and one with tap water.

Having the settling process recorded on film, the character of the flocs, the clarity of the supernatant, and the settling time were evaluated visually.

The experimental work was divided into two test series. The first was to investigate the most effective combination of coagulant-polyelectrolyte, and the second to compare the most effective coagulants and their combinations, and were designed to obtain supernatant with pH close to neutral.

No success was encountered during the preliminary investigations using cationic, anionic or nonionic polymers alone or in conjunction with lime and soda when the pH was less than 10.

The first test series showed that lime, Ca OH, was the best coagulant, followed by caustic soda, alum and sodium-aluminate. The sodium-aluminate was not efficient and was, therefore, dropped from further tests.

The pH of the supernatant was either alkaline or acidic and, of course, in a practical application would require neutralization, especially when the settled particles were concentrated in the bottom of the settling tank, and dissolution of the copper has to be avoided.

In the second test series, the effects of the concentration of selected coagulants on the settling time and on the pH were found to be highly significant. Some of the results are tabulated in Figure 6. Lime in combination with alum, or soda with alum, give settling rates higher - and with bigger flocs - at lower chemical consumption, than either of these coagulants alone. Moreover, the pH of the supernatant is close to neutral.

Considering the settling characteristics of the flocs, as well as these figures, the best results are with combinations of chemicals as in Samples B2 and B1 in Test Series 8.

The following figures are typical of one of the tests:-

Figure 7: shows the end of the mixing period and the start-up of the settling time (0 min.). The first cylinder on the left contained the original untreated sample. The second cylinder contained the sample treated with the combination of lime, alum and polyelectrolyte. The third contained the same sample treated with

sodium hydroxide, alum and polyelectrolyte. The fourth is the same but with different proportions of soda and alum. The fifth is the same as the second but with different proportions of lime and alum. The sixth cylinder contains tap water.

Figure 8: shows the same group of samples after 30 seconds. The highest settling rate is in the second cylinder - Sample B2.

Figure 9: shows the samples after 1 minute; Figure 10 - after one minute and 30 seconds; Figure 11 after two minutes; and Figure 12 after six minutes.

Samples B2 and B1 are comparable to tap water in clarity, whereas samples B3 and E2 still contain fine unsettled flocs. If the sample in the first cylinder were left to settle for 60 hours, the colour would be unchanged.

These pictures show very clearly what can be achieved by coagulation, flocculation and settling in this particular case.

The next step was to try the most effective combinations of inorganic coagulants and polyelectrolytes in a pilot plant. A scale model of the proposed system was built to 1/8" scale and installed at the Brockville Plant. This gave us a readily available unlimited supply of samples, unaffected by the transportation from Brockville to Sheridan Park. A schematic diagram of the unit is shown in Figure 13.

This was operated for a period of some ten working days, both draining the effluent and recirculating it. During these tests, the effluent was always clear and the concentration of copper less than 1 p.p.m.

On the basis of these results, full-scale plant treatment was designed by the Ontario Research Foundation and implemented by Phillips as shown in Figure 14. To utilize the existing equipment only small changes were actually needed.

In the settling tank a simple flocculation chamber was built as shown in Figures 15 and 16. The water flows in through the central pipe and then through a distributor which gives it a tangential movement. This dissipates the energy and ensures fairly efficient flocculation.

The bigger flocs, due to their higher settling rate, pick up the finer particles moving slowly down, increase their size, and ensure that at the bottom of the chamber, the larger flocs predominate.

A secondary ring-like chamber forms a collar around the primary chamber, trapping a blanket of flocs, which act as a sort of filter - and eventually overflow, settling down on the bottom of the tank.

The settling rate of the bigger flocs, as measured in the laboratory, is about 2 ft./min. while the rate for the finer particles is about ¼ to ½ ft./min. As the upward flow in the tank is less than 1/100 ft./min. by calculation, there is ample excess capacity.

Under these circumstances it was possible to achieve more than 99% reduction in the copper content of the effluent without any major changes in the plant equipment.

It was found that due to the large volume of the settling tank, precise feeding of chemicals was not essential. In fact, at the beginning, we dumped it in by the gallon. A cheap and simple gravimetric system is sufficient, although metering plunger pumps have actually been used instead.

After the full-scale operation was implemented, the plant worked very satisfactorily. Frequent tests are made to monitor the quality of the effluent and the amount of copper is well below the minimum required.

Figure 17: shows the quality of the effluent before and after treatment.

One of the most interesting aspects of this treatment is the economic one. The dosage of chemicals does not require additional personnel and the capital costs were quite reasonable, using as we did, already existing facilities.

Figure 18: shows the calculated costs of materials based on prices late in 1970. The fresh water used for lubrication comes from the river and, as we have excess pumping capacity, this is not included in the costs. The final objective is the re-use of this water as bearing lubricant, and this step is imminent.

The calculated cost - approximately 7¢/1,000 gallons - is much less than for simple sand filtration through graded media. If the recovered copper is included in the calculations at 40¢/lb., then the treatment is paid for by the recovered metal with additional savings of approximately $9.00 for an 8-hour day.

You may be wondering why we chose to use sodium hydroxide rather than the more efficient calcium hydroxide, or lime. You will recall that I mentioned that copper in the solid form is not harmful. Copper in solution, however, is a different matter, and we had some of this to deal with.

When the copper rod is produced in the mill, it is covered with a thin layer of black oxidized copper. This must be removed before further processing and we do this by a pickling process in dilute sulphuric acid. When the coils of rod leave the pickling bath they are sprayed and rinsed with water to remove the carry-over. This spray water contains small amounts of dissolved copper in the form of copper sulphate. The permissible amount that is unharmful to aquatic life is 0.025 p.p.m.

The spray water is, therefore, treated to precipitate the copper and one of the reagents used in this treatment is sodium hydroxide.

Having a supply already on hand, therefore, made it the logical choice.

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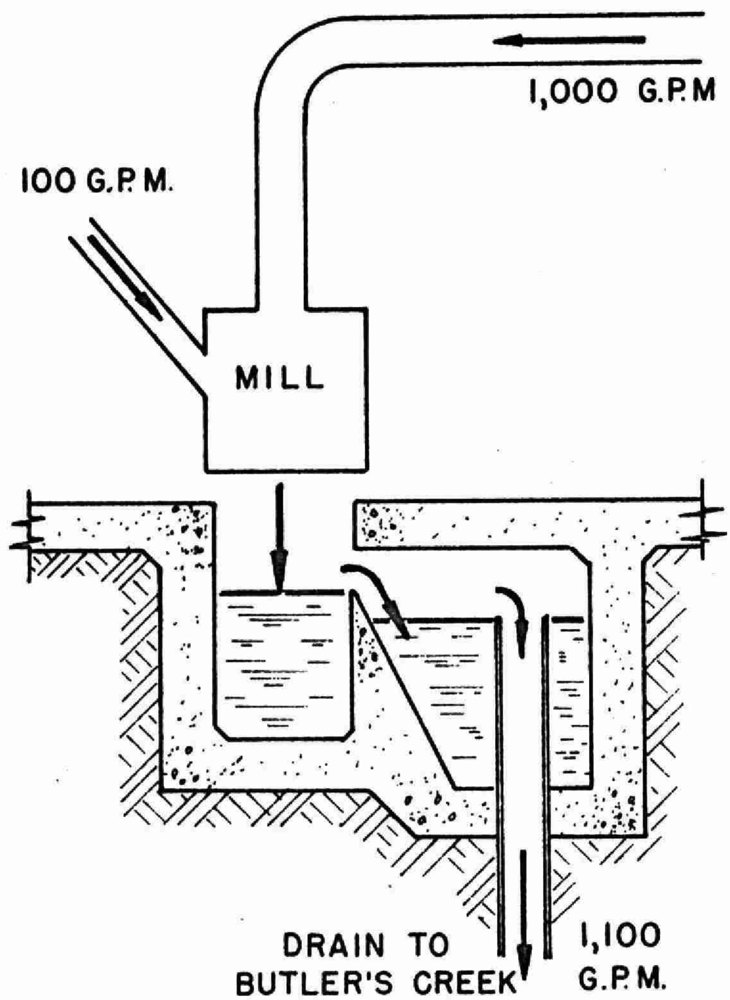
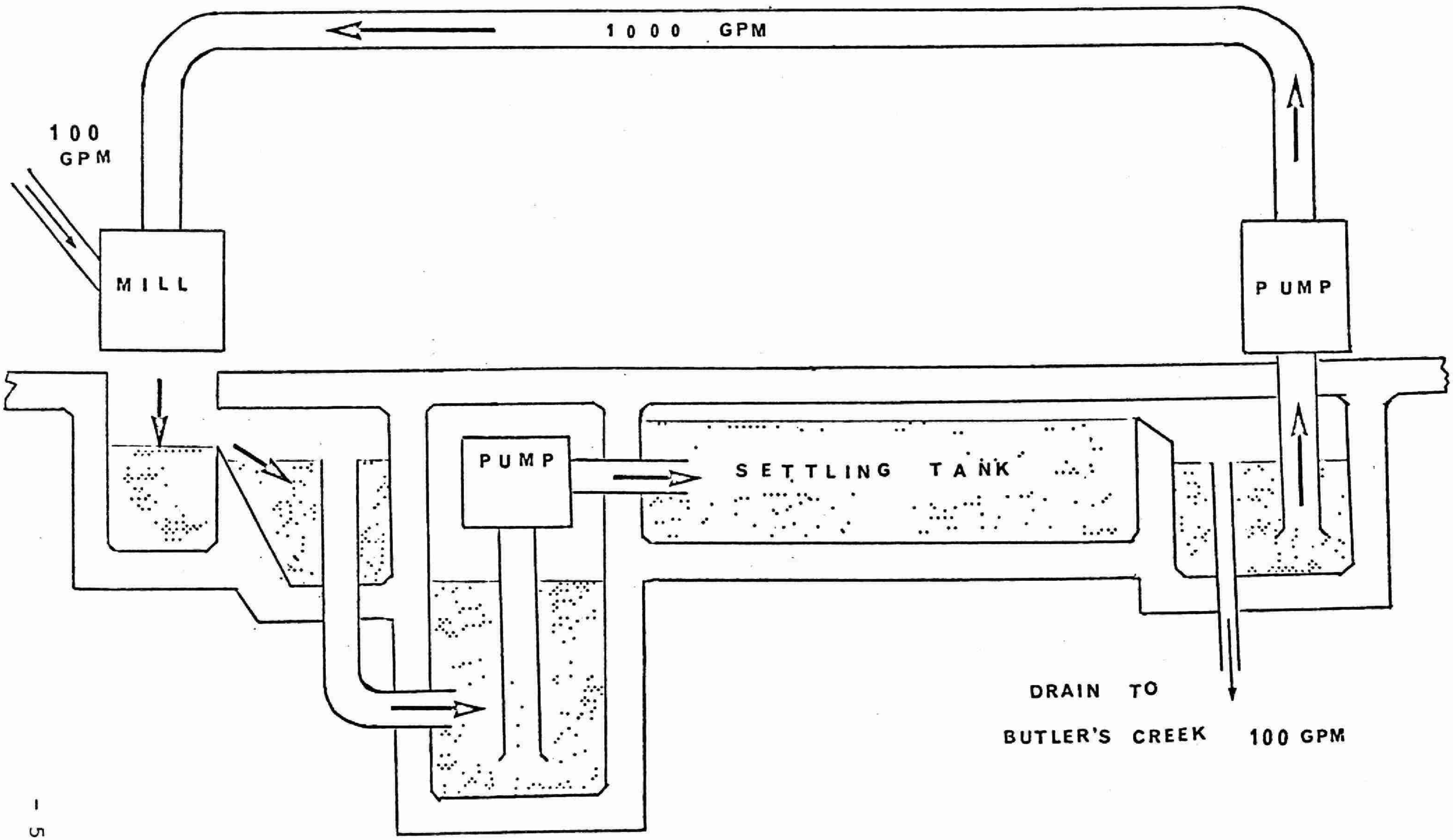


FIG. 1

FIG. 2



1 0 0 0 GPM
100 GPM
MILL
PUMP
PUMP
SETTLING TANK
DRAIN TO
BUTLER'S CREEK 100 GPM

FIG. 3

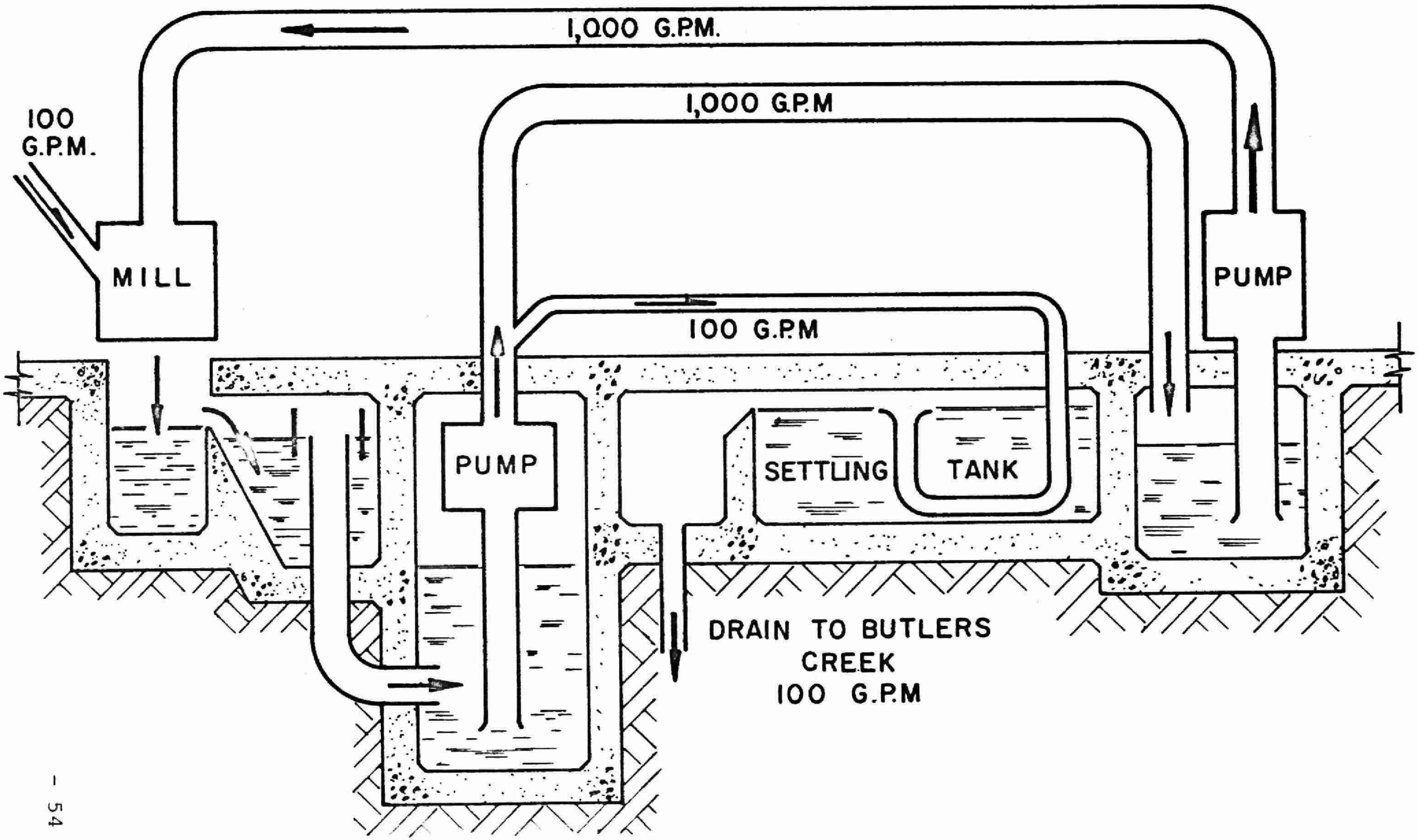

1,000 G.P.M.
1,000 G.P.M
100 G.P.M.
MILL
PUMP
100 G.P.M
PUMP
SETTLING
TANK
DRAIN TO BUTLERS CREEK 100 G.P.M

FIG. 4

TABLE I

Concentration of the Copper in the Waste and Effluent Streams

Date 1970	Time	Feed into Sett. Tank ppm	Effl. From Sett. Tank ppm
March 16th	10.29	100	80
" 16th	13.16	80	65
" 17th	8.39	95	55
" 17th	13.43	90	56
" 18th	11.08	95	75
" 18th	15.25	105	80
" 19th	9.32	80	57
" 19th	12.27	80	60
" 20th	10.30	60	50
" 20th	15.00	75	55
" 23rd	13.00	70	50
" 24th	13.30	55	65
" 26th	13.30	60	50
" 31st	13.30	90	55

FIG. 5

TREATMENT OBJECTIVES

(1) Reduce the concentration of the copper in the effluent below 1 ppm.

(2) Recovery of the copper as a byproduct.

(3) Reuse of the clarified effluent for lubrication of the roll bearings.

(4) Totally eliminate the contamination of the Butler's Creek by copper.

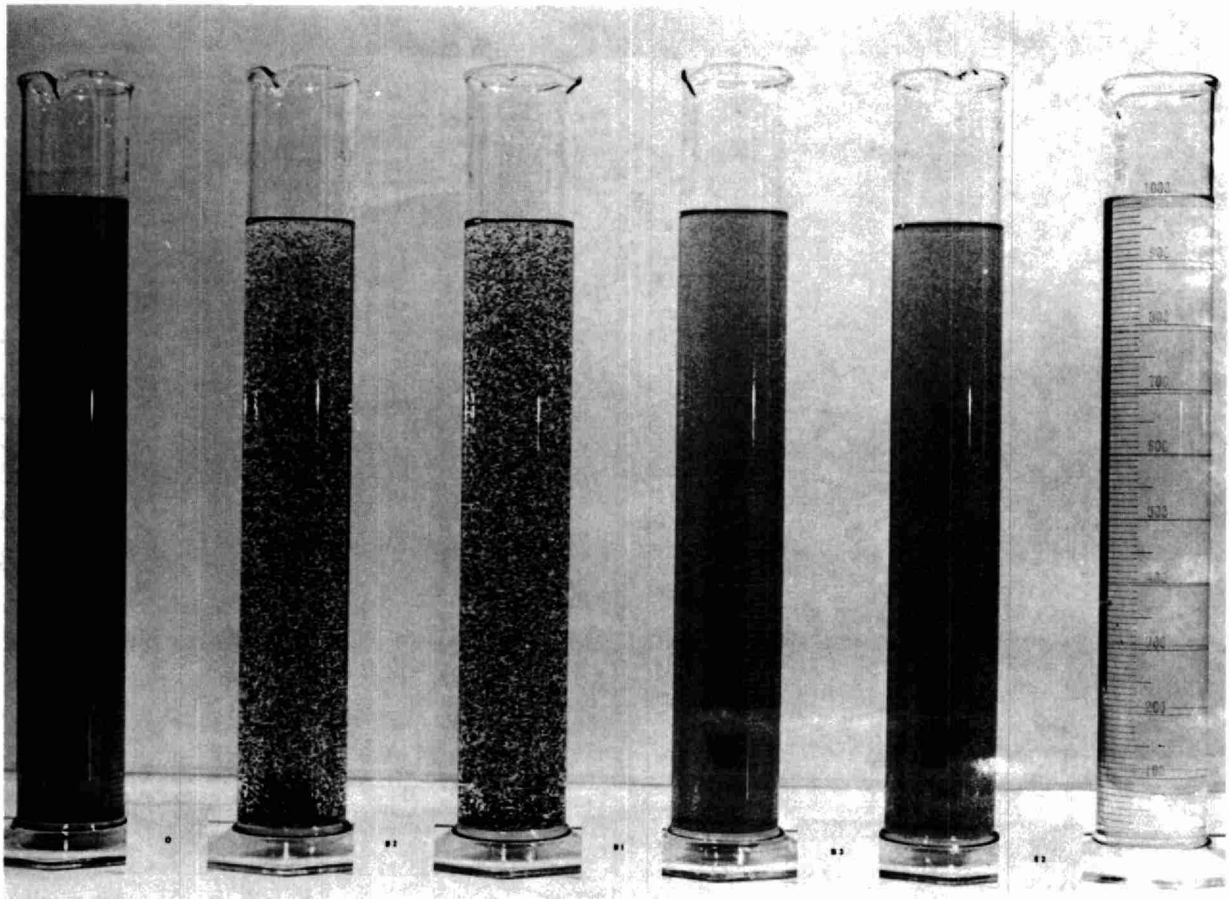
FIG. 6

TABLE II

	Test No. 6.				Test No. 7.			Test No. 8.			
SAMPLE:	B2	A2	A3	B3	B1	B2	B3	B2	B1	B3	E2
Coagulant											
Na $(OH)_2$ (mg)	400	200	200	-	100	150	200	100	-	-	50
Na OH (mg)	-	-	-	-	-	-	-	-	50	60	-
Al_2 (SO_4) 16 H_2O(mg)	-	200	350	400	150	225	300	150	150	140	150
Polyelectrolyte H - 817 (mg)	3	3	3	3	2	2	2	1	1	1	1
Settling order	2	1	4	3	1	2	3	1	2	4	3
Settling time (min)	2.5	2.5	5.0	5.0	1.5	2.0	2.5	1.5	2.0	5	5
Supernatant clarity (degree 1,2,3)	1	1	1	1	1	1	1	1	1	1	1
pH	11.5	10.0	7.2	4.7	7.9	8.4	9.8	8.0	7.3	7.8	7.3
Fc c/1000 US gal	6.30	9.50	13.1	12.7	6.5	8.7	10.9	5.5	7.1	7.4	5.1

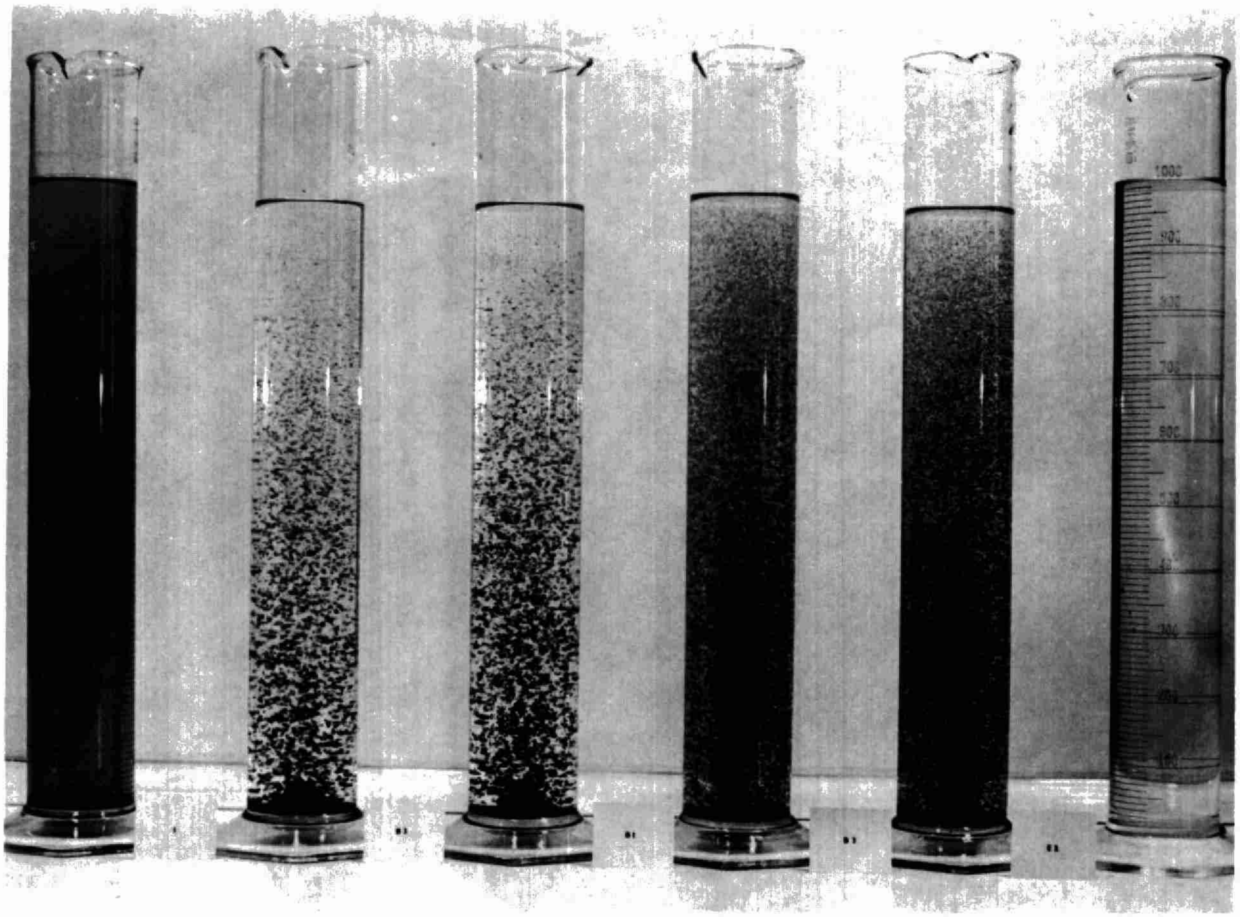
Conditions for test series II

Waste water: copper 90 mg/l; pH = 8; samples = 1000 ml



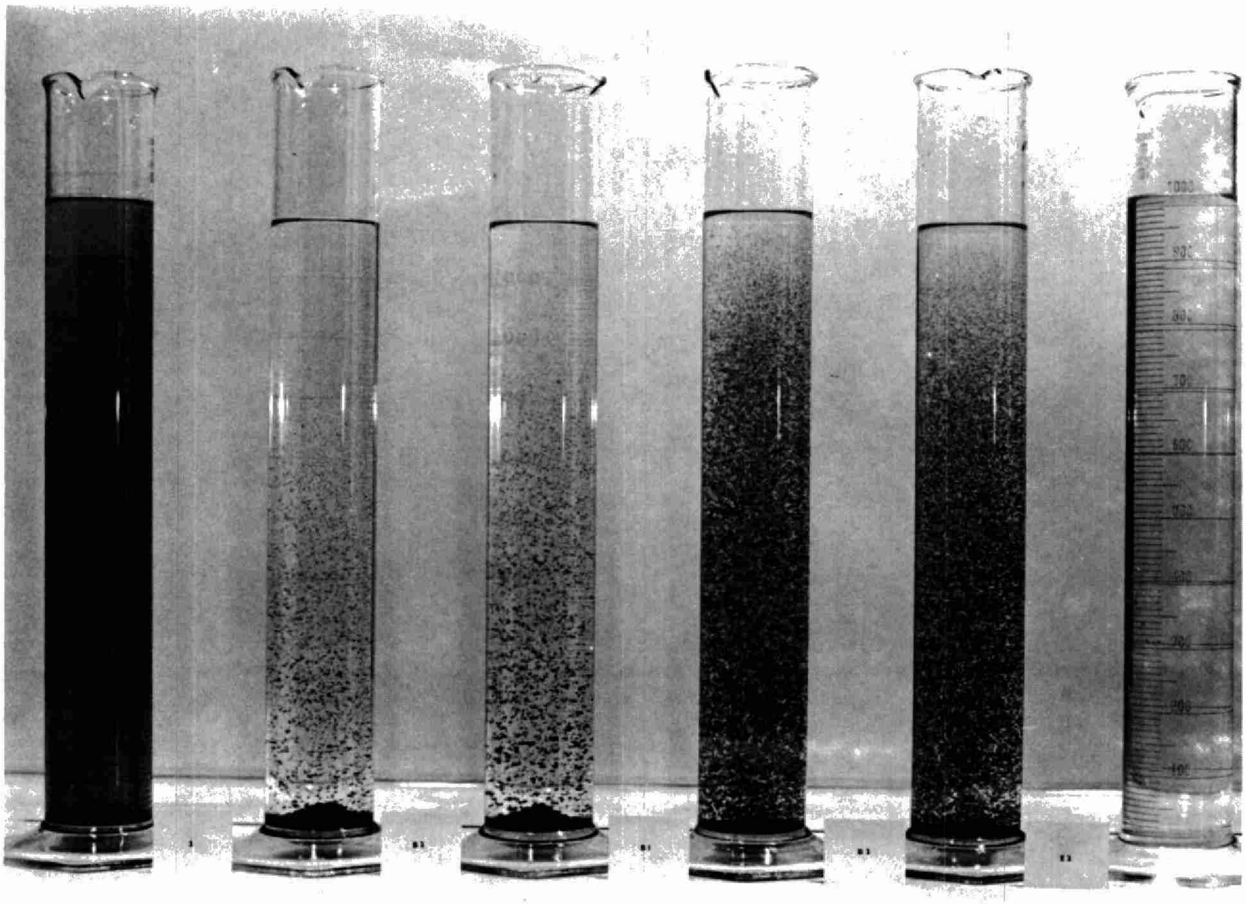
0 B2 B1 B3 E2

FIGURE 7



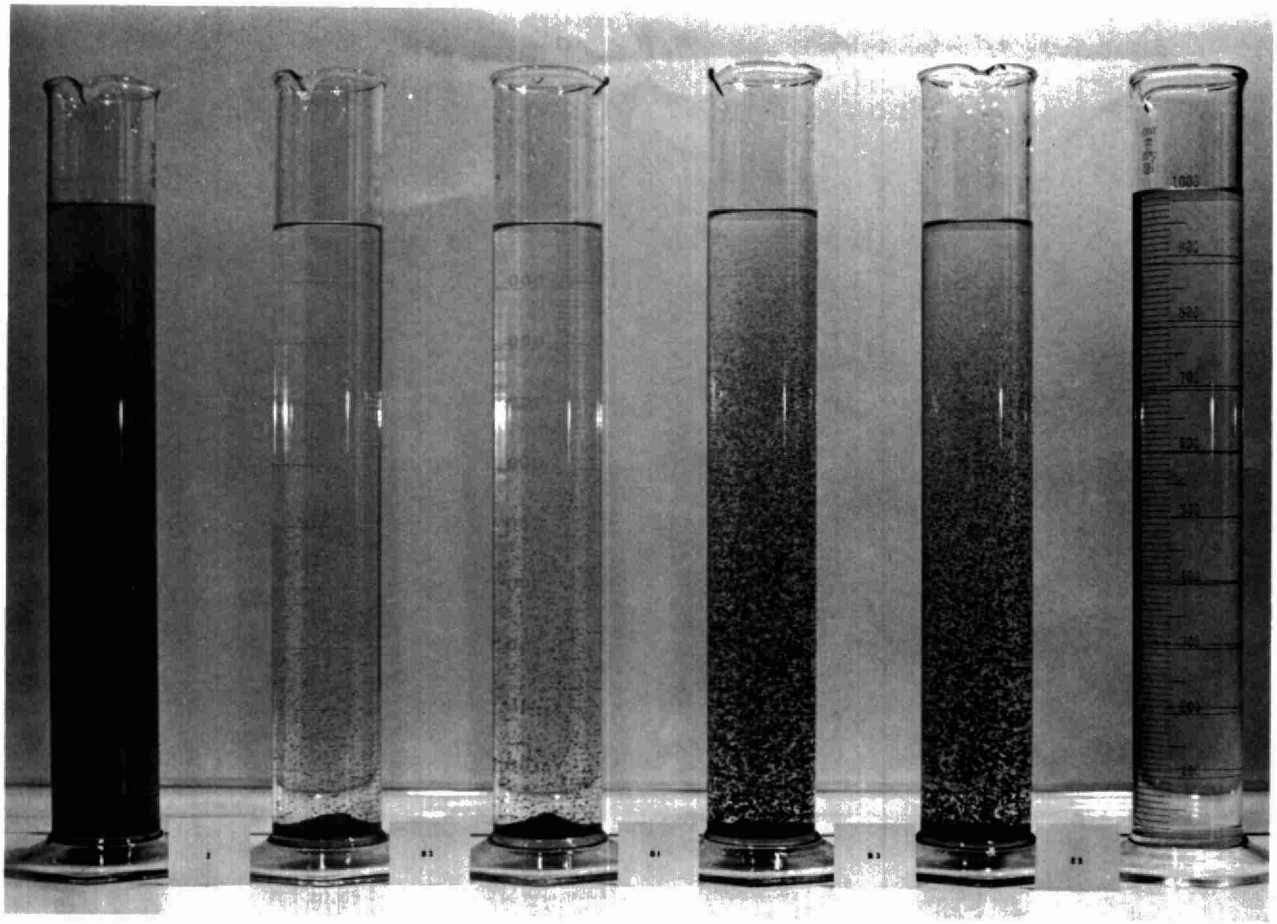
1 B2 B1 B3 E2

FIGURE 8



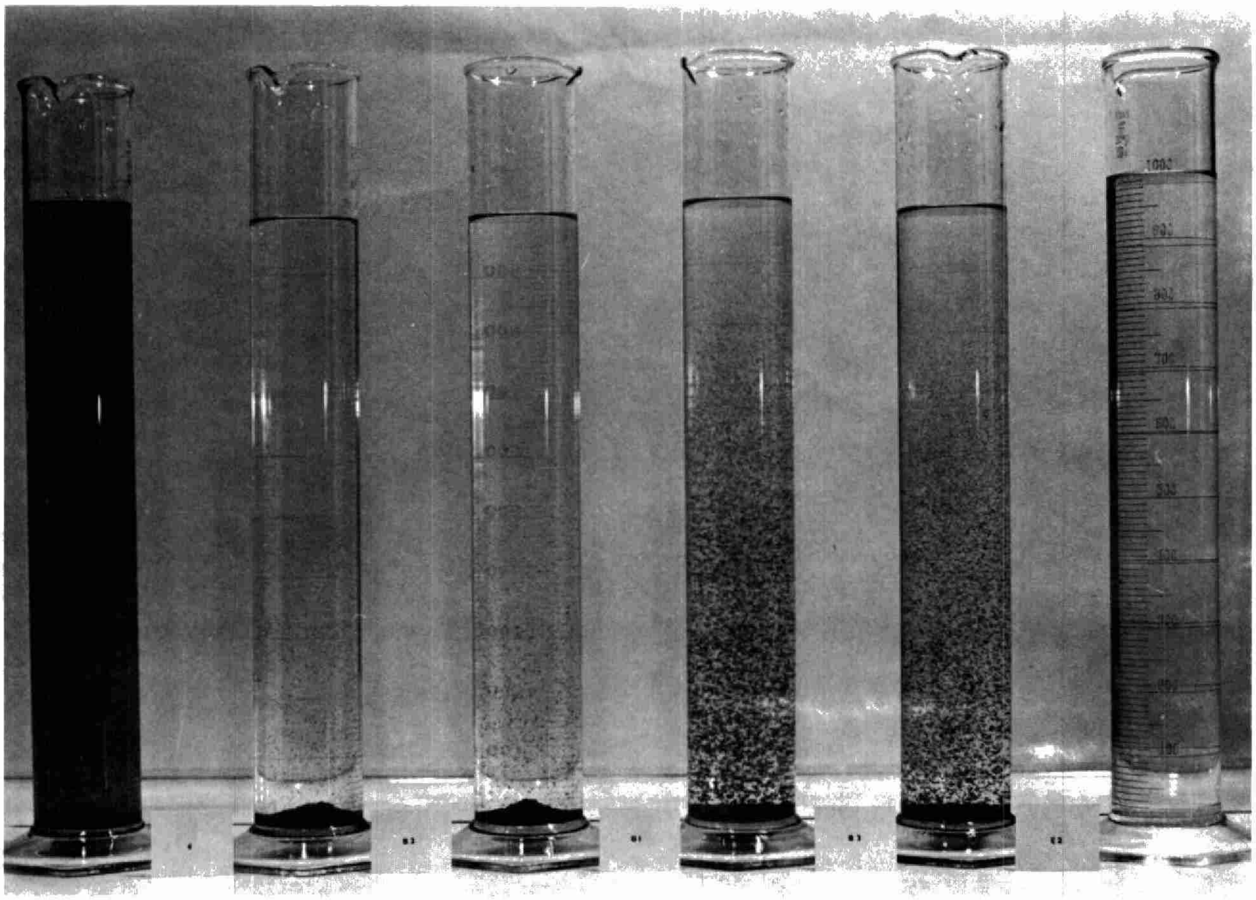
2 B2 B1 B3 E2

FIGURE 9



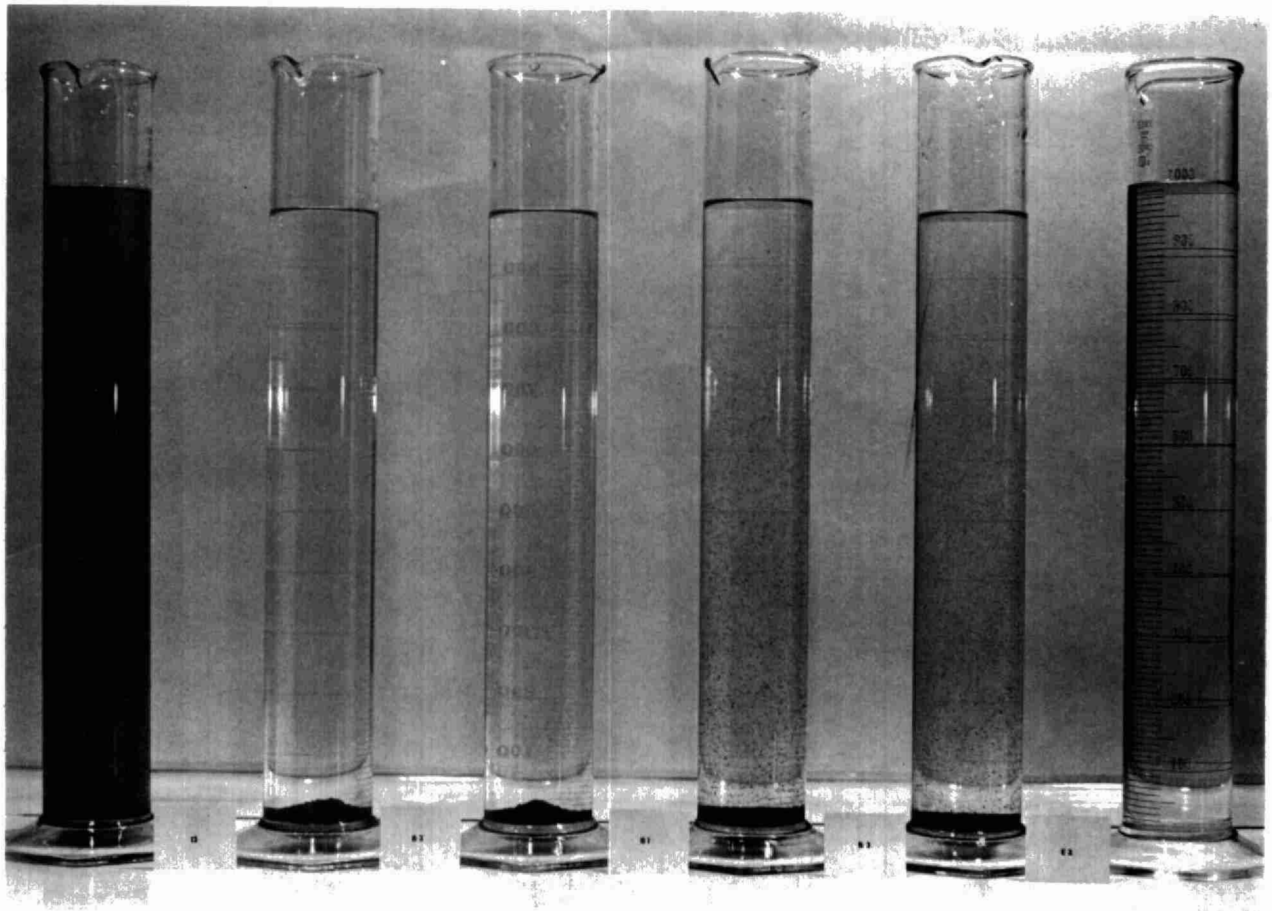
3 B2 B1 B3 E2

FIGURE 10



4 B2 B1 B3 E2

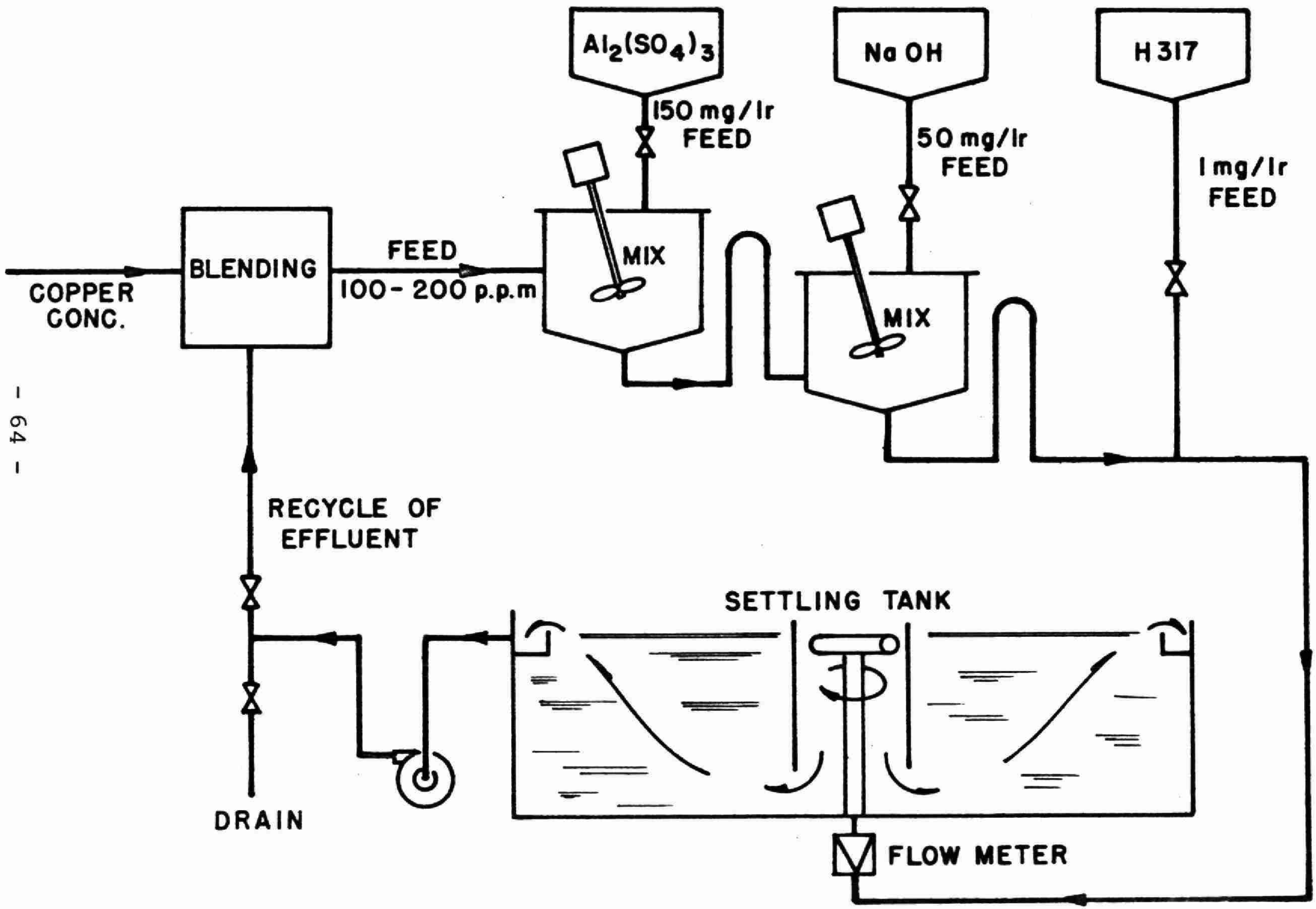
FIGURE 11



12 B2 B1 B3 E2

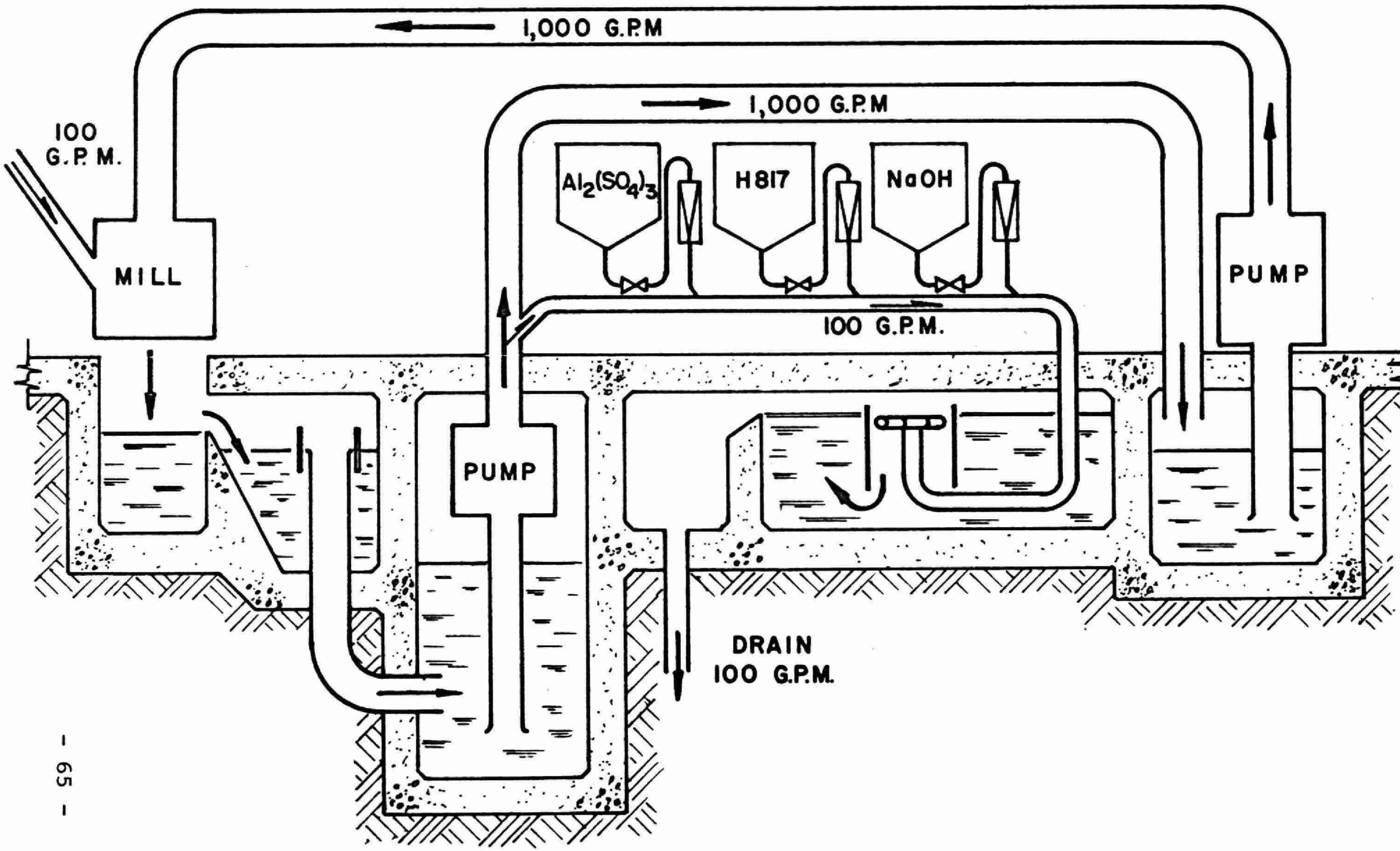
FIGURE 12

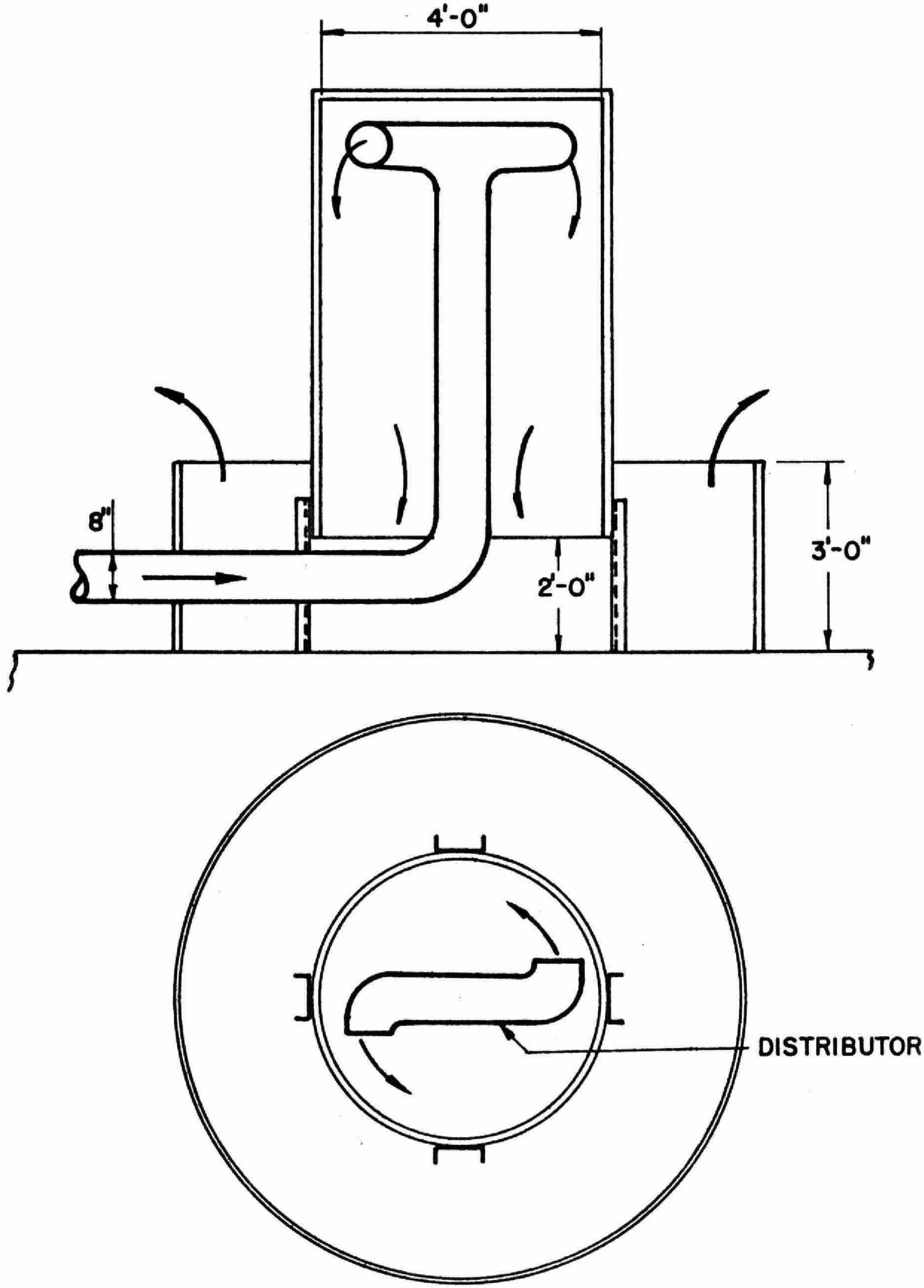
FIG. 13



$Al_2(SO_4)_3$
150 mg/lr
FEED
Na OH
50 mg/lr
FEED
H 317
1 mg/lr
FEED
COPPER
CONC.
BLENDING
FEED
100 - 200 p.p.m
MIX
MIX
RECYCLE OF
EFFLUENT
SETTLING TANK
DRAIN
FLOW METER

FIG. 14

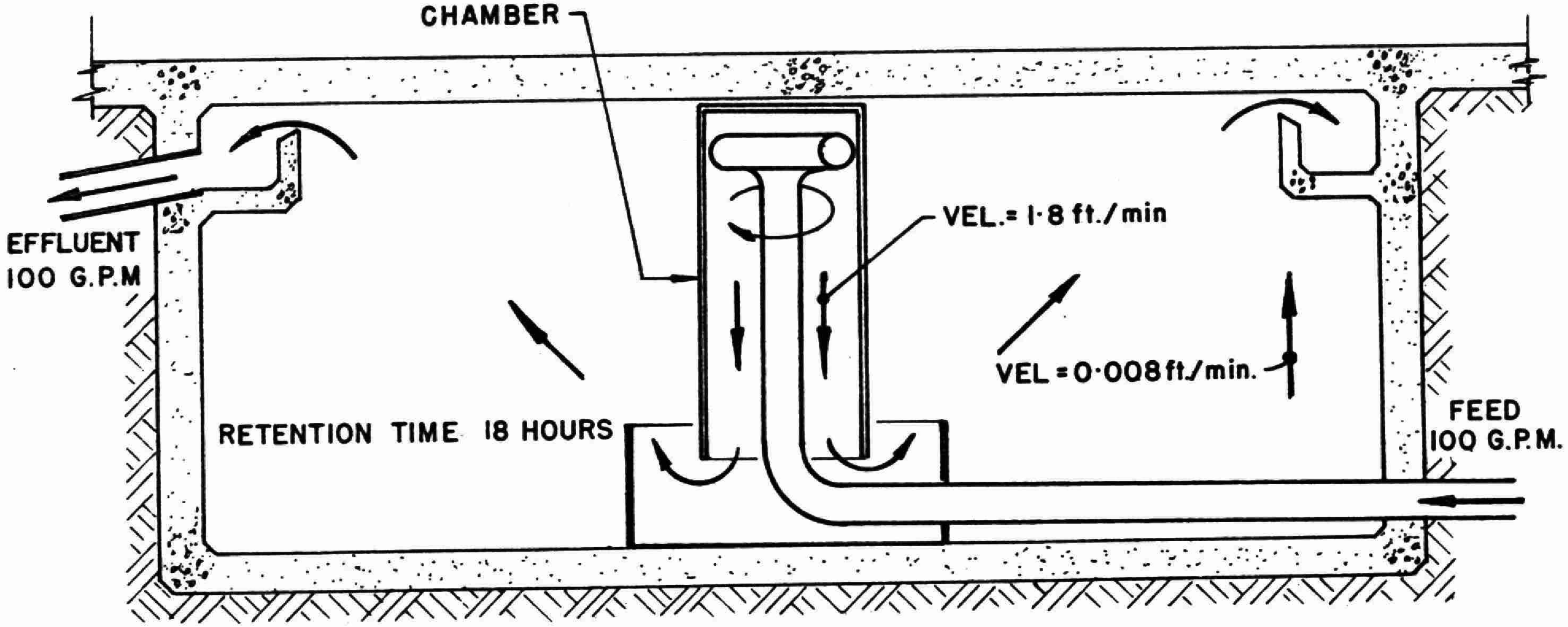

1,000 G.P.M
1,000 G.P.M
100 G.P.M.
MILL
$Al_2(SO_4)_3$
H817
NaOH
PUMP
PUMP
100 G.P.M.
DRAIN
100 G.P.M.



FLOCULATION CHAMBER

FIG. 15

FIG. 16



SETTLING TANK

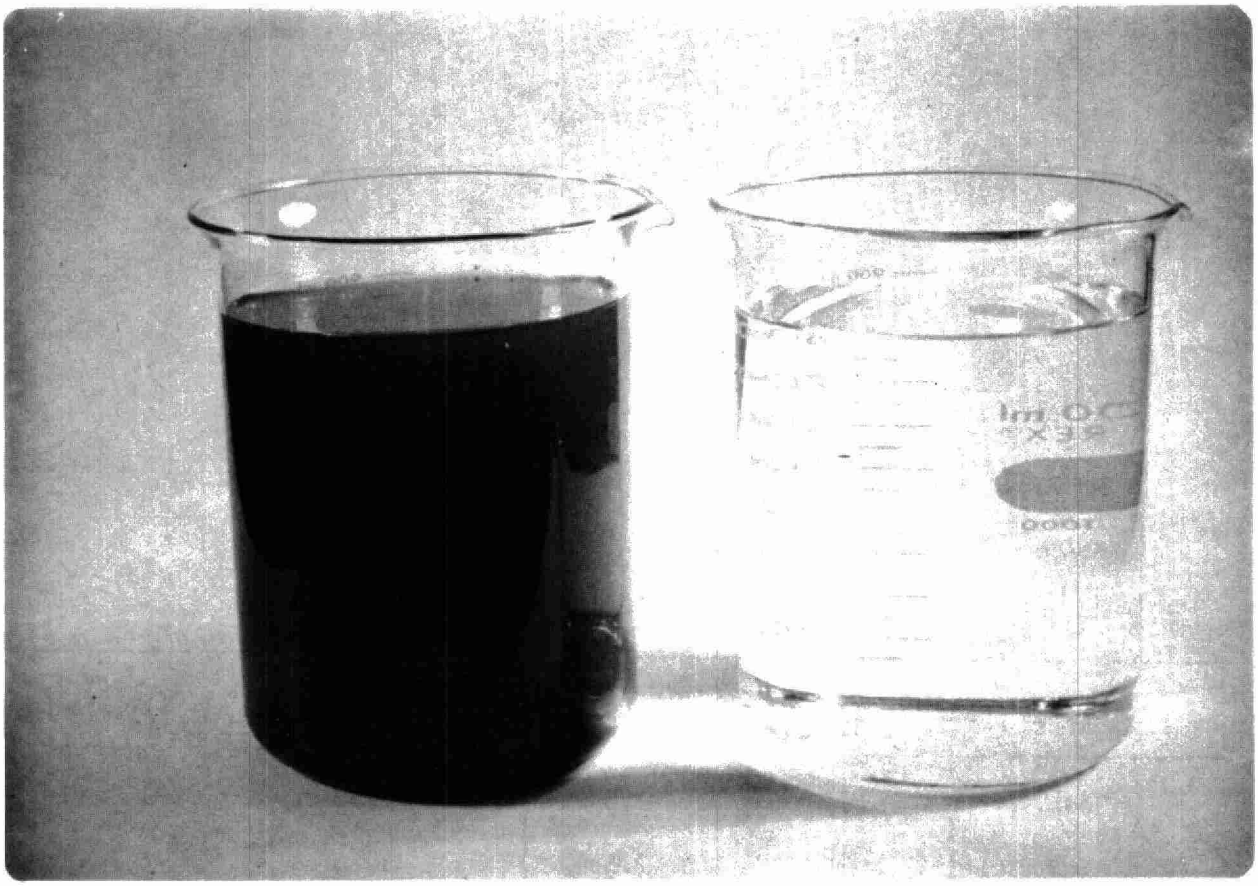


FIGURE 17

FIG. 18

TABLE II

MATERIAL COSTS FOR NEW TREATMENT
Flow: 6000 U.S. Gal/hr; conc. 80 mg/l
NaOH - 50 mg/l; $H_2(SO_4)_3$ 16 H_2O - 150 mg/l; H817-1mg/l

No.	Materials	Unit Price ¢/lb.	Consumption lb/hour	Cost ¢/1000 U.S.gal.	Cost $/16 hours
1	Soda	6.00	2.5	2.50	2.40
2	Alum.	2.91	7.5	3.60	3.45
3	H-817	119.00	0.05	0.99	0.95
4	Total			7.09	6.80
5	Recovered Copper	40.0	0.667 lb/1000 gal.	26.70	25.50
6	Net Savings (5-4)			19.61	18.80

J.E. Kinney

"ASSESSMENTS OF POLLUTION ABATEMENT PROGRAMS"

BY

JOHN E. KINNEY,
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In the United States the environment is fast being taken over by the lawyers and the insects. There are indications Canada will follow suit unless the people of Canada can appreciate the mess inevitably developed by political solutions to pollution. My commentary is prompted by the hope that a frank assessment of the conflicting forces in American pollution control efforts will prevent repetition of the errors.

The recent announcements of a joint Canadian-American commitment to clean up the Great Lakes, the Canadian adoption of legislative limitations on phosphate in detergent with the present American hassling over a similar decision, and the conflicts among adopted and proposed state, provincial and federal laws on vessel pollution are but some of the evidences of interrelationships of the programs of these two countries.

With the tendency of the press of both nations to play on the emotions of the readers and with the competitive spirit promoting each to outdo the other, the Canadian people could, with advantage, ask the question the American people refuse to consider

whenever they are offered an environmental forecast, an assertion of polluted conditions or a remedial proposal. The question is a simple one: "Is it true?"

We tout the need for education and provide a budget second to none for its availability and for research into the technical, social and economic aspects of living, but then when we provide for a multi-billion dollar program via legislation, a program which will affect the vitals of our living, we blithely assume the political act of appointing the head of the program will endow that individual with the knowledge requisite for effective implementation, and we question neither the accuracy of his appraisal nor his proposal.

The fiction goes further. Failure to achieve the desired objective is seldom attributed to incompetence in the individual but rather there is agreement the problem has worsened due to unanticipated complications, and a further enactment will undoubtedly provide the remedy. Of course it doesn't, but the action keeps conversation going and away from the issue competency.

If the failure is patently obvious, there are two other approaches to quiet the restless natives. The first is to reorganize -- "a wonderful method it can be for creating the illusion of progress while producing confusion, inefficiency and demoralization." The second is to employ the artful dodge of resurrecting some rule, regulation or law which was a failure in its original intention and interpret it anew to mean some totally different objective.

These ploys have become our way of life in pollution control in the United States. There is a direct correlation between the volume of legislation and the gravity of the situation, as the press views it. Each new federal and state enactment is justified with the assertion the situation has worsened; each is praised and adopted as the answer. The only assured result, however, will be the need for further legislation. There is also a direct correlation between the number of reorganization plans and the loss of competent, technically qualified personnel at state and federal level. Each reorganization places another level of technically unqualified, political appointees between the staff and the problem. Competent staffers see professional responsibility diluted with political expediency and refuse to participate. The law of diminishing returns sets in and soon the level of incompetency is such that the agency is incapable of doing the job even with dictatorial authority.

So then the third correlation becomes evident -- between increasing incompetency in solving technical, social and economic issues and promulgation of rules and regulations. Enforcement of the rules and regulations gradually substitutes for achieving the original objective.

This is so for the simple reason that the individuals who cannot comprehend the essence of the problem nor suggest the solution must resort to certitudes -- in fact, as de Jouvenel pointed out, such individuals stand in physical need of certitudes.

The rationalization of less-than-competent individuals in assuming positions of authority seems quite simple. To them, the objective is one of administering a law and they argue a person of average intelligence should do the job if there is a staff of technicians subject to call. Moreover, when the pay is good, being in the spotlight carries a demand for deference which appeals to many.

The rationalization at the end of tenure is as simple. But the consequences are not simple. In fact, they are diabolical in the area of environmental control.

Many factors contribute to this growing way of life, but among the primary is the altogether too common attitude of the legal mind that the law per se is supreme. Reducing a problem to a law and enforcing the law is the essence of government. The rule of the majority or the rule of the minority may be argued as preferable but all agree some rule must be adopted.

With too few exceptions, the legal mind has become institutionalized. In fact, it has become hypnotized by the belief that each problem is simply reduced to a rule or regulation which, upon proper application to a court of designated jurisdiction, may be provided with exceptions if the need develops.

Because this modus operandi controls man with varying degrees of success, the legal mind had no difficulty attempting to extend it to nature. But nature allows of no exceptions or flexibility nor does it permit the man-made laws to compete with the natural. Thus an error in the assumptions on which man-made laws are premised will eventually demand a penalty. The error spells failure even for efforts bathed in gold or promulgated with eloquent oratory.

Charlie Brown, the Peanuts character, summarized quite nicely the frustration of the proponents of such regulation: "Why can't I win when I am so sincere?" Nature accepts only the deed; the wish is immaterial.

Nature is an entity and any effort to codify the parts, to consider a part as an entity which is to be controlled by rules, regulations and laws, is doomed, for the parts are so interrelated they are not separable. Joint and several applies not to nature.

Nor does it apply to the environmental concepts of man. Environment is the summation of what exists: the social, cultural, economic and physical aspects of our being. It thus continues to exist because of or even despite the efforts of man. It can be

expenditures for so-called purity divert funds from other environmental blights such as ghettos, crime on the streets, malnutrition and educational needs; or they can be economic by forcing the closure of marginal industries and thus increasing unemployment and causing an increase in social problems as well as the costs attendant thereto.

We have no planned environment. There is no forum at which agreement can be reached on the environment desired. Rather our environment is the result of the many bureaucratic programs coupled with private interest activities. Since each program and activity considers its mission or objective as controlling, there is a monumental stress, not domestic tranquillity.

The forces in this environmental stress are many and competing. When any given aspect is overworked or overprotected, others feel the impact. Unfortunately, the legal profession, though increasingly involved - sometimes voluntarily, sometimes in a compulsory, self-defence role - has not yet demonstrated a knowledge of the totality of the environment nor the concept of eventual consequences. Admittedly the rules of the game of law have been well established and changes are slow, but if the environment is really as important as the present attention would suggest, the legal profession should analyze its traditional attitudes and consider the desirability of new objectives and roles.

Bluntly speaking, to the lawyer the name of the game is winning the argument and the approach to winning is more frequently effected by utilizing precedent. The win by one is matched by a loss or inconvenience to another. Whether the effect is on an individual, a crowd, or even a nation, a later decision can reverse the effect should there be a change in policy or in philosophy. But decisions in major environmental issues produce irrevocable results and unfortunately, courts which are not knowledgeable in environmental issues cannot perceive the danger of precedents. The same act in different places can produce drastically different effects.

Because the objective is now limited to winning the game the United States Department of Justice has experienced no compunction in utilizing a semicolon in a section of an 1899 Rivers and Harbors Act to assume jurisdiction over the industrial discharges of the nation. By this action the agency ignored the 1965 Water Quality Act, a later enactment, which should be controlling even if the interpretation of the 1899 Act were correct. That the Department of Justice can ignore an enactment by

utilizing a derelict law is only part of the story. So is the evident capacity to ignore the canon dinned into the minds of first-year law students that an enactment must be considered in toto.

The Assistant Attorney-General published guidelines in 1970 defining the intent of both laws and insisting pollution cases have to be prosecuted under the 1965 Act, that the 1899 Act was to be limited to occasional big losses. So when a spokesman for the Corps of Engineers in Chicago announced the guidelines had been withdrawn without explanation, there was disbelief. Now that the Justice Department has announced its 27 actions are to be the precedents for civil actions to close industries under the 1899 Act, there is disgust by those who have worked diligently in government and private industry for abatement of pollution and protection of the environment. Word is that the Department of Justice in a June conference of the Attorneys-General will outline these precedents and then allow the generals a field day closing down industries.

The Department of Justice has not distinguished itself by joining in the Administration effort to distract attention from the 1965 Act, which has the name of Muskie attached to it. Justice has announced it is moving against "flagrant violators" who are not under orders from either state or federal agencies. The facts don't support the halo. Department of Justice spokesmen admit it is most difficult to actually prove damages from an industrial discharge so the approach is to seek indictments against companies which discharge cyanides, phenols and heavy metals, constituents which by nature are toxic so the judge will know they are toxic and thus the Department of Justice won't have to prove damage. To ensure success, the actions are against companies which the Department of Justice expects will seek a nolo plea and accept the stipulations of a consent decree to save the cost of a court fight or to dodge adverse publicity. Some companies concede simply to determine what must be done to prevent further harassment.

The decision may be a victory for the Department of Justice and a precedent for further action against industry, but the decisions are essentially bad law for they afford no protection for the total environment.

For example, the scientific illiterates who have publicly proclaimed their intent to prevent discharge of coke plant waste because it contains cyanide and phenol, announce they would save the environment by requiring incineration of the wastes. Trace

concentrations of cyanide and phenol, even though the poundage may seem considerable, are really insignificant in the industrialized waters, for they are easily oxidized in the stream. It is ironic that members of the Bar cannot perceive how a fifth of booze consumed in an hour is pollution, even toxic pollution, but a fifth in a week is plasma; that it isn't the load but the concentration which is important. But the millions of cubic feet of natural gas required for incineration accelerates depletion of limited supplies and creates air pollution problems. Thus the vanity of an individual can leave an indelible and worse imprint on the environment.

To aggravate this travesty the Corps of Engineers is promulgating an application questionnaire to be filled out for a permit for each industrial sewer. The form of two parts has an instruction booklet of 118 pages accompanying it. But the form is as remarkable for what it does not ask as it is for the information requested. Nowhere is there required information as to what the stream standards are that are to be met or what the resultant river quality will be. The data call for instantaneous maximum concentrations and maximum discharges in pounds per minute for a litany of constituents. The information cannot be used by the Corps to determine effect on the water resources even if the Corps had a competency in this field. And filling out and getting approval for these forms will delay the whole program. The head of the Corps estimates up to three years to issue permits. There are no specific standards, so an applicant has no basis for determining whether the proposal will be acceptable. Moreover, the cost of filing and monitoring to meet requirements will cost several hundred million dollars a year, at best estimate.

What should be noted is that the form is arranged for a computer layout which can be geared to a pollution tax and to a proposal for effluent standards in terms of pounds of pollutant per ton of product. The next stage is to relate the poundage in the discharge to the consumption of raw material -- that information is also requested in the Corps of Engineers application form -- and thus set the stage for a direct taxation of the use of the water resource in terms of the raw material used in production.

The Nixon Administration is desperately attempting to find a new source of revenue. Lack of encouragement for a tax on value added prompted the proposal for a tax on the use of the air and water resources as public goods used for private gain. To this is attached a punitive tax on pollutants as a palative to sell it to the public as an environmental improvement. Although Canada seemed to favour the concept, there was lack of support in the countries of western Europe and Japan when they were asked to adopt the same

technique. They had the foresight to realize it would disrupt internal economy by levying a disproportionate cost on the competing industries using more air and water. They could also see how this extra cost of production would be disadvantageous in dealing with communist countries unless there was further government subsidy.

That this approach to revenue would force closure of marginal industries is obvious. What the effect would be on the local tax duplicate and on the people thrown out of work can be imagined. But these aspects of environmental quality are ignored in the desperate effort for funds. Also ignored is the fact that the quest for clean air and water -- the cloak under which this offer is hidden -- can be forgotten.

Lack of foreign enthusiasm for this act prompted the Administration to promote precedent anyhow by a tax on sulphur and lead. Close attention to the propaganda on these efforts discloses the fact that even when the standards are met, the tax will continue on the thesis that the residual sulphur and lead in the atmosphere might be harmful and a tax, if high enough, would tend to discourage its use.

If there were even a reasonable basis for believing sulphur and lead now cause impairment to health, they should be limited or banned -- and would be if the government accepted its responsibility to the citizenry. But if there is no reasonable basis to believe harm to health, there should be no fraudulent advertising promising health benefits from such a tax.

If the Administration wants money and wants to employ a tax on non-desirable activities such as discharges of lead and sulphur, then why shouldn't the Administration extend the principle to all non-desirable activities. For instance, homicide is a non-desirable activity (and it also creates more cases of fatal lead poisoning than all the gasoline fumes and industrial discharges together), and a graduated tax increasing according to the degree up to first degree murder would certainly be a possible consideration. If you pay a tax, the economist suggests the discharge of lead will not cause pollution -- regardless of standards. Why not use the same argument on homicide or burglary or vandalism? It is equally fallacious, if there is a desired quality of life as an objective.

The income from the liquor tax is the best assurance the Volstead Act won't be repeated. But now we run a parallel in banning other so-called environmental hazards and then allow for the continuance if a tax is paid.

Another legalism in controlling the environment is now receiving attention in the United States. When the Congress voted against the SST, a drive was initiated to have Congress vote on the Alaskan pipe line. Some conservationists are applauding this democratic way to stop an undesired action. However, since the Congress has no independent agency to which it can refer for a qualified appraisal of consequences and alternatives to action and since the Congress has no technical competency but merely is responding to the demands of the mob, the only solace is to recall that in recorded history the people have never been wrong.

There are some 40 proposals in the Congress to ban or limit phosphate in detergent principally because an Administration political appointee couldn't respond adequately to a Congressional political polluter who was seeking headlines. Now local politicians are emulating this self-professed authority for the same reason. Also involved are the so-called public interest law firms which would suggest their role is to defend the environment against industry and government. The demands of members of Congress who support this approach can be credited with much of the data demanded on the Corps of Engineers application form. The data are then self-indicting in actions by citizens to close industries. The history to date of these actions points up the difficulty generated by a myopic approach. The theme of these organizations is that man has a civil right to an environment as clean as the technology of the moment will permit. Cost is no consideration. And neither is the consequence.

For example, when the Environmental Defense Fund demanded the elimination of DDT, there was no attention to the lack of a substitute for DDT to control bats and mice. Now the Environmental Defense Fund has modified testimony submitted about regulations on usage of DDT, and, in effect, admits a lack of data to support the scare allegations.

When one asks why the citizen isn't entitled to as clean and healthy environment as is possible, EDF goes into a shell. The City of Detroit is being forced to spend $100 million to meet federal regulations for advanced waste treatment, purportedly to protect Lake Erie. There is, however, a drastically cheaper approach which would provide the protection the expensive technique will not. But Detroit is conforming to regulation, not intelligently abating pollution. However, because the funds are so committed, Detroit is faced with reducing police and fire protection and limiting collection of garbage to every other week. This last is truly an environmental disaster because it will allow an explosion in rat population -- Michigan is a leader in banning DDT -- and rats are a prime vector in transmission of disease.

But Detroit isn't alone. Canadian cities have rodent control problems of serious proportions. Since rats are directly related to human health, the question becomes: Why can't a child be as important as a fish?

Obviously, if our technical problems are to be resolved by legal arguments, we must realize a smart attorney can develop a most convincing argument when he relies on the assertions found in press, periodicals and government agency pronouncements. Devoid of technical knowledge in this field, he can assume the accuracy of the instances he selects to support his contention. Half-truths are common in environmental exposes, so the article of many references is often more proof of wide reading than knowledge. The Case-Western Law Review, for example, some months ago had a classic example of how the facts can be distorted. But it read well. And its anti-corporate flavour appealed to those who would transfer industrial corporate management to public trustee.

There are other legal involvements which deserve attention. The citizen action suit has a good promotional effort but the fault lies in making the accused prove his innocence -- a major change in the tenets of American jurisprudence -- in courts which are not really knowledgeable about the environmental impact of the issues they would decide. The incredible aspect is that this concept is promoted by liberal lawyers who want the principle applied only to industry, not individuals.

The result of the recent wholesale intrusion of lawyers -- as politicians, claimants or public servants -- is that now in the United States there is no-one to whom a municipal official or industrial manager can go and determine specifically what standards he must meet or whether installation of specific treatment facilities will be acceptable for even a reasonable period of time. Effective, continuing progress is impossible.

This fact is evidence that the do-gooders and politicians have booby-trapped the pollution abatement program. Consider an example. A steel company was constructing facilities approved by the State of Ohio at its Cleveland works when the company got notice from the Federal Environmental Protection Agency that that agency had unilaterally assumed full jurisdiction over the company and would set requirements. This action developed from its own interpretation of the federal law -- which, incidentally, has less than unanimous agreement -- that by issuing 180 day notice, EPA decides what standards and time schedule must be adopted by a company or city. The procedure calls for an informal public hearing at which the state is an observer and public opinion can be louder than facts. However, in this instance, before the 180 days were up and while the company

was redesigning to meet EPA requirements, the Federal Department of Justice obtained an indictment and is negotiating a consent decree calling for further changes in the program.

Unfortunately, the company is still vulnerable, for it must now seek a permit from the Corps of Engineers, and that permit could be conditioned on other requirements. The local district engineer has discretionary authority approaching that of an absolute monarch.

And to frost the cake, the application for the permit will include data available to the public which could be used in a citizens' action against the company. In some states, such as Michigan, the court has the authority to decide what constitutes pollution and what must be done about it. The same crusaders who promoted the state laws are now promoting similar legislation at federal level. Since these individuals really accept no responsibility for the long-term consequences of their actions, they qualify as enviromaniacs.

Meanwhile, the state agencies which have the only real competency are reduced to pawns by the federal permit system -- whether it be under the Corps of Engineers or EPA. Since the company must eventually get approval from some federal agency, why should it expend any money until there is a decision as to which federal agency controls and a decision not only as to what that agency wants but whether it is really compatible with federal law.

To make matters worse, the federal pollution control agency has shown a willingness to change signals frequently, so there is no incentive for a state agency to proceed with enforcement. There is no incentive for an industry to guess what it should do. The federal permit system places industry under federal control but cities remain the responsibility of state enforcement. The impossibility of a coordinated program is obvious.

The federal-state relationship in the United States had degenerated before the Nixon advisors grabbed the 1899 Act bait developed by some Democratic Congressmen. Ignorant in environmental quality and pollution control, these newcomers ballyhooed the 1899 Act as the panacea for quick action to the point where backing down is intolerable. But unless they do devise a retreat strategy, the pollution abatement program in the States will be totally stalled within six months. Then it will be a flag for the Democrats for the next election. The stalled program will be cause for conservationists to criticize the States and the States will be justified in defending themselves. So the situation will worsen even further.

The Nixon Administration has moved into the war on pollution in the same manner as the Johnson Administration moved into the Vietnam war. Neither had a defined objective; neither anticipated consequences; neither could pass up the political expediencies of the moment; neither knew how to retreat. Both are programs which affect the way of life and the pocketbooks of the citizens; both promote inflation; both affect employment as they proceed with changes in direction; both make unattainable promises; both waste resources and manpower.

Control the water resources and you control the economic development of the nation. Thus control over the Great Lakes will be the long-term decision maker in differences between the United States and Canada.

But control over the water resources is merely one facet in the environmental control sought by man. Domestic tranquillity is a higher goal and more descriptive of a desirable environment.

However, domestic tranquillity results only when the spiritual, cultural, social, economic and physical aspects of man are in harmony with each other and with nature. Attaining such an objective requires the development of a forum at which all the needs of man are appraised and agreement reached on the kind of environment we want. We have no such forum now.

Then we need the administrative mechanism for defining alternatives in reaching the goals, with costs and benefits (economic, social, and physical) for each alternative.

This means a separation of fact-finding from policing and regulation; assignment of priorities in needs and remedies; quantitative definition of estimates of effects of proposals so rational resolution of specific differences can be attempted.

Now that policing of pollution has been removed from the United States Department of Interior, that agency is accepting responsibility for telling the public the truth about the quality of land and water. The agency has recently released Geological Circular 645, "A Procedure for Evaluating Environmental Impact", which I commend to you as a practical methodology for anticipating and quantifying impacts of alternative proposals on the physical environment. A similar methodology is desired for social and health impacts of proposed ventures.

But these ideas are barren unless the technically competent assume first class citizenship and assert the facts. Political

pollution is inundating our social and economic structures. It can be halted only with facts, accurately interpreted and properly presented to the people.

Who shall lead? Lawyers? Politicians? The voice of the people in polls and petitions? Or those knowledgeable by education and experience?

We can easily rationalize not being leaders. We can even rationalize an exaggerated and distorted emphasis on pollution if it directs more money to research, enforcement and construction. But in either case the penalty is large -- the price is our dignity, our freedom, and a perversion of natural and human resources.

There is an even more imminent danger to the peoples of Canada if the technically competent don't assume leadership, quiet the hysteria and block legislative answers to technical problems. Under the umbrella of joint American-Canadian programming, the Canadians will be hornswaggled into adopting agreements spawned in an atmosphere of crisis by a jamboree of scientific illiterates but limited to political expediency and promoted by a most effective hysteria propagandizing organization. The net effect will be international control over Canadian development even though the title is pollution control. The consequences merit your attention now.

I would hope the Canadian people would learn an even more important lesson from the American political pollution fandango; a lesson offered in the warning of Edmund Burke in 1775 in his final effort at conciliation between England and the Colonies. His review of conditions between the Parliament and the Colonies bears remarkable resemblance to our present federal-state relations; so too was his description of the mood of the people relative to taxation which returned no positive benefit.

Burke's prophecy of trouble could be well heeded today. Just as then, the people will eventually learn their increased taxes are not achieving the promised quality environment under presently proposed programs and the tax revolt already in evidence could explode. Just as then, the bureaucracy of many faces has neither environmental direction nor competency and thus no sincere interest in the specific areas. The growing distrust of federal dictation will raise no defence for the federal establishment against the revolutionaries.

The answer, if there is to be one, is to decide locally the kind of environment the people want, the approach to be taken to achieve it, the priorities in its attainment, and the time schedule which local financing will permit.

This is not our way in the United States, and Canadians should clearly see that the American way is not achieving success and should not want to be involved in it.

At local level, agreement can be reached albeit with difficulty. No agreement can be reached with a many-faced entity which is not coordinated in itself.

Facts, commonsense, and plain dealing can make the difference. This audience contains a wealth of facts and commonsense. Has it got the interest and the initiative to force the plain dealing?

SESSION CHAIRMAN,
MR. A. CLARK ELLIOTT,
SUPERINTENDENT, UTILITIES DEPT.,
THE STEEL COMPANY OF CANADA, LTD.,
HAMILTON, ONTARIO.

J.R. Hawley

"ASPECTS OF THE PROBLEM OF ACID MINE DRAINAGE IN THE PROVINCE OF ONTARIO"

BY

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Introduction

The rapid industrial development and utilization of natural resources in the Province of Ontario has presented many problems concerning our water environment. A tremendous upsurge in mining exploration and development in the past two decades plus uncorrected situations having origins in the mining activities of the early part of this century have resulted in serious deterioration of the quality of the water in many watersheds of the north where mining operations are carried out.

Acid mine drainage is a major environmental problem in Ontario's hardrock mining districts. Curiously enough, most specific acid mine drainage problems are not the result of indiscriminate hardrock mining activity but, instead, form a condition of it. The problem may occur whenever an orebody containing iron sulphides is exposed to the atmosphere.

The problem of acid mine drainage is not unique to Ontario. It is well known in other Provinces, the United States, Europe and Japan. In fact, acid mine drainage probably occurs on a worldwide basis.

The problem of acid mine drainage in Ontario begins when a mine-mill operation, during the processes of ore comminution and beneficiation, discards, as waste, the various iron sulphide minerals that occur naturally in the ore. These iron sulphides, finely divided as a result of milling operations, are, along with other gangue (non-valuable) materials discharged as a slurry to a natural or man-made settling basin that is commonly referred to as a tailings area. Here, the slurry undergoes a natural solid-liquid separation and, under ideal conditions, the solid particles, including the iron sulphide minerals, are retained within the confines of the tailings area. The clarified liquid escapes the area via a structure called the decant and as seepage through the bases of permeable dams.

Once in a tailings area and after a varying period of time, the iron sulphide minerals react to form water soluble salts which, when discharged in the effluent from a tailings area, can affect stream chemistry and stream ecology.

The Chemistry of Acid Mine Drainage

This paper deals exclusively with the type of acid mine drainage problem that results when naturally occurring inorganic sulphides undergo spontaneous decomposition. The basic reactions that describe the chemistry of this type of situation are as follows:

Reaction #1 (Sulphide to Sulphate)

When natural sulphuritic material in the form of a sulphide (and usually in combination with iron) is exposed to the atmosphere (oxygen), it may theoretically oxidize in two ways with water (or water vapour) as the limiting condition:

(a) Assuming that the process takes place in a dry environment, an equal amount of sulphur dioxide will be generated with the formation of (water soluble) ferrous sulphate:

$$FeS_2 + 3\ O_2 \dashrightarrow FeSO_4 + SO_2$$

(b) If, however, the oxidation proceeds in the presence of a sufficient quantity of water (or water vapour), then the direct formation of sulphuric acid and ferrous sulphate in equal parts results:

$$2\ FeS_2 + 2\ H_2O + 7\ O_2 \dashrightarrow 2\ FeSO_4 + 2\ H_2SO_4$$

In most mining environments (underground as well as in the tailings area), the above reaction is favoured.

Reaction #2 (Oxidation of Iron (Ferrous to Ferric))

Ferrous sulphate in the presence of a sufficient quantity of sulphuric acid and oxygen oxidizes to the ferric state to form (water soluble) ferric sulphate:

$$4\ FeSO_4 + 2\ H_2SO_4 + O_2 \dashrightarrow 2\ Fe_2(SO_4)_3 + 2\ H_2O$$

Here water is not limiting since it is not a requirement for the reaction but rather is a product of the reaction.

Most evidence seems to indicate that a specific bacterium (T. ferrooxidans) is involved in the above reaction and is responsible for, at least, accelerating the oxidation of the ferrous iron to the ferric state.

Reaction #3 (Precipitation of Iron)

The ferric iron associated with the sulphate ion commonly combines with the hydroxyl $(OH)^-$ ion of water (HOH) to form ferric hydroxide. In an acid environment, ferric hydroxide is largely insoluble and accordingly precipitates:

$$Fe_2(SO_4)_3 + 6\ H_2O \dashrightarrow 2\ Fe(OH)_3 + 3\ H_2SO_4$$

IMPORTANT NOTE

The ferric ion can and does enter into an oxidation-reduction reaction with iron sulphide whereby the ferric ion "backtriggers" the oxidation of further amounts of sulphuritic materials (iron sulphides, etc.) to the sulphate form thereby accelerating the acid-

forming

flotation. Unfortunately, the iron sulphide minerals in the ore must also suffer the fine grinding procedure. As the grind becomes finer, the relative surface area of each sulphide particle increases. As the relative surface area of each sulphide particle increases, the probability of an acid mine drainage situation increases. Two years ago, a mill grind of 65 percent minus 200 mesh was common. Today, grinds finer than 300 mesh are becoming common.

The iron sulphides, pyrite, pyrrhotite and marcasite are not the only sulphides that are discharged to a tailings area. There are over 125 naturally occurring inorganic sulphides and sulphosalts and many of these are well known 'ore' sulphides. Since mill efficiencies are seldom greater than 97 percent, limited quantities of these sulphides also gain access to a tailings area. The 'ore' sulphides are subject to chemical attack especially under the extreme conditions that are created by the oxidation of the iron sulphides.

Some metals, cobalt and nickel for example, can substitute for iron in the iron sulphide lattice. When the iron sulphide lattice breaks down, these metals also go into solution if the sulphide is in an aqueous environment.

Acid conditions are frequently generated in underground mining environments where oxygen-carrying water is permitted to come into contact with sulphide-bearing rock masses. This water must be removed from the mine and its disposal is a problem.

Typical acid mine drainage flows are characterized by a low pH, a high iron concentration, a high sulphate concentration and an abnormal heavy metals concentration. Manganese, copper, cobalt, zinc and nickel are all commonly found in acid mine drainage flows. The list of the possible anions and cations that can occur in an acid mine drainage type effluent is almost endless.

Soluble iron compounds, which are an integral part of most acid mine drainage flows, tend to oxidize over a period of time. The resulting complexes or finely-divided precipitates are various shades of yellow or red in colour. Amber stagnant pools of this type of waste and yellow-tinted seepage flows typify a mining camp

that is, or has been, subject to acid mine drainage.

The development of an acid mine drainage situation at a mining property is probable if:

(a) the ore (including country rock) being milled contains iron sulphide minerals; and

(b) the ore (including country rock) does not naturally contain enough carbonate or similar material to effectively neutralize all the 'acid' that will result from the decomposition of the iron sulphides.

The probability of an acid mine drainage situation increases:

(a) with an increase in fineness of grind in a mill circuit. As the grind becomes finer, the total available surface area for reaction increases.

(b) with an increase in the number of permeable dams on the property or with an increase in the length of existing permeable dams on the property. Seepage flows through the dams act as the transport medium for the soluble reaction products of sulphide decomposition. If the soluble reaction products are not removed, connecting pore spaces in the tailings mass become clogged with these substances and the acid mine drainage mechanisms are forced to slow down because of a lack of available oxygen, water and soluble ferric iron.

(c) with the return of untreated seepage from the bases of dams to the main tailings area. In acid mine drainage situations, untreated seepage contains quantities of dissolved ferric iron. This ferric iron can cause the oxidation of further amounts of iron sulphide should it come into contact with iron sulphide.

Chemical Treatment of Acid Mine Drainage

The treatment of acid mine drainage at the present time involves some form of neutralization. Neutralization is necessary to control pH and to precipitate soluble metallic species. In some instances, neutralization to a minimum pH of 8.5 is sufficient. In other instances, a minimum pH of 8.5 will still leave a few metals in solution. Accordingly, the pH must be

increased until, if technically feasible, total precipitation is achieved. Where the pH is increased to a very high level (over 10) to achieve total precipitation of the metals, adjustments will be required to reduce the pH to normal levels prior to discharge to a watercourse.

Generally, five common neutralizing agents are available for use:

(1) ammonia
(2) sodium hydroxide
(3) sodium carbonate
(4) limestone
(5) lime

Because of its toxicity and nutrient properties, ammonia should never be used as an effluent neutralizing agent. Similarly, the use of ammonia and ammonium based compounds in a mill circuit should be avoided.

Sodium hydroxide and sodium carbonate are both acceptable as neutralizing agents but, because of their costs, do not find wide use. There is, however, an ecological advantage in using sodium carbonate as it will tend to offset any inorganic carbon deficiency in water that may result from discharges of the acid mine drainage type.

Lime and limestone are the most commonly used neutralizing agents. Lime finds the greatest use and, from a chemical standpoint, is the preferred reagent. Lime is generally available, has a high basicity and the cost, while high, is less than all other neutralizing agents with the exception of limestone. Lime is a very reactive material with the neutralizing reaction going to completion within one hour. High pH's can be obtained and maintained with lime. In Ontario, where the removal of inherent heavy metal concentrations is required, this capability is very important.

The attractiveness of limestone as a neutralizing agent centres primarily on its low initial cost per unit weight and the fact that it presents almost no problems with regard to handling and storage. Its disadvantages, however, are numerous. The limestone

neutralization reaction is slow and often requires from 24 to 48 hours to go to completion. The long detention time that is generally required after limestone addition to an acid effluent becomes significant when the land upon which the retention facilities are built is expensive or when numerous impoundment structures are required. Aeration may reduce the retention time to one comparable to lime. Neutralization with limestone tends to become inefficient above pH values of 4.0. pH's above 7.0 are obtained and maintained with some difficulty. Total utilization of the potential alkalinity of limestone can drop to approximately 31 percent. In contrast, the utilization efficiency of lime is generally in excess of 97 percent. During the neutralization process, the limestone particles become coated with insoluble reaction products. If this coating is not continuously removed, the reaction is retarded. In any case, the limestone reaction seldom goes to completion and the resulting limestone sludge contains a residual alkalinity that is of questionable value. Limestone, under most circumstances, exhibits an inability to effect complete control of dissolved ferrous iron whereas lime handles this material with relative ease. In Ontario, where acid seepage flows frequently contain considerable concentrations of dissolved ferrous iron, this is an important factor. One dubious advantage of the limestone reaction is that it is not very sensitive quantitatively and therefore the accuracy with which limestone is fed into an effluent stream need not be controlled to the same degree as that required by lime.

Fixed beds of limestone are not recommended for neutralization of final effluents.

When acid mine drainage conditions prevail, iron is the principal metal found in solution. Depending on many factors, the iron will be either in the suspended or dissolved form and in the ferrous (Fe^{++}) or the ferric (Fe^{+++}) state. In the pH range below 3.0, most of the ferrous and ferric iron will be in solution. In the pH range 3.0 to 8.0, the ferric iron should all be in a precipitate form and, while much of the ferrous iron will also be in a precipitate form, a significant portion of the ferrous iron will also be in solution. In the pH range above 8.0, essentially all iron species are insoluble and hence precipitate. In acid mine drainage circumstances, ferrous and ferric

iron are generally associated with the sulphate radical. Ferric sulphate hydrolyzes in an aqueous environment to form an insoluble hydroxide plus sulphuric acid. The acid released can cause a pH depression. Ferrous iron in a stream will oxidize to the ferric form and then hydrolyze to form the hydroxide and sulphuric acid. Since ferrous iron exhibits a greater stability in acid and somewhat alkaline environments than does ferric iron, the ferrous ion has the potential ability to migrate much farther from a tailings area than does the ferric ion. However, as the distance between the ferrous ion and the tailings area increases, conditions for the survival of the species deteriorate, and, ultimately, oxidation and hydrolysis takes place.

Several chemical agents which are indigenous to mine drainage waters have been cited in the literature, in various circumstances, as displaying catalytic properties in the oxidation of ferrous iron. These include inorganic ligands, such as sulphate, which coordinate with iron (II) and iron (III); soluble metal ions such as copper (II), manganese (II), and aluminum (III); suspended material with large surface areas and high absorptive capacities such as clay particles; and materials which accelerate the decomposition of peroxides in the presence of iron (II) such as charcoal.

Microbiological Aspects of Acid Mine Drainage

A topic that is frequently associated with the subject of acid mine drainage is microbiological leaching of sulphide minerals. Microbiological leaching involves the oxidation of the sulphide portion of various metallic sulphides with the subsequent release of the metal values into solution. Three names have been given to bacteria capable of oxidizing sulphide minerals:

(1) Thiobacillus ferrooxidans;
(2) Ferrobacillus ferrooxidans; and
(3) Thiobacillus sulfooxidans.

However, it has been shown that there is no justification for separating the bacteria into different genera and species and, as such, the name T. ferrooxidans has been suggested for the group.

Like many bacteria, T. ferrooxidans is ubiquitous, and its activities are manifested in leach-

ing wherever a sulphide substrate, oxygen, carbon dioxide, water, certain essential nutrients and the correct pH make up a suitable environment.

T. ferrooxidans belongs to a somewhat select group of bacteria which are rather independent in temperament, and which probably existed on this earth long before those other microbial forms which are interdependent for many of their foods and conditions of life. In contrast to most bacteria, T. ferrooxidans uses atmospheric carbon dioxide as its sole source of the carbon necessary for the generation of cellular material. Rather than utilizing organic matter such as fats, carbohydrates or proteins as a source of energy, this organism cannot even tolerate their presence, and obtains its energy solely by the oxidation of inorganic materials such as ferrous iron or sulphur in the form of elemental sulphur or as metallic sulphides.

T. ferrooxidans has adapted itself to live and grow in the strongly acidic environment (pH 1.5 - 3.0) which results from the oxidation of sulphides, and in the presence of many heavy metals which are released into solution from minerals concurrent with the oxidation of ferrous iron and sulphides. In order for T. ferrooxidans to function in the biological leaching of sulphides, the pH must be below 4 and preferably below 3. Apparently, the organism can oxidize sulphur at pH's as high as 5, but it will only occasionally oxidize sulphide at pH's above 3.5, and never above 4.0.

In attacking the sulphide moiety in crystalline or amorphous substances, the bacteria convert the sulphide to sulphate and, with the disruption of the solid matrix, the metal ions go into solution. These metals remain in solution as water-soluble sulphates initially, although iron may be subsequently precipitated as the insoluble hydroxide or basic sulphate. The hydrolysis of the ferric sulphate produces sulphuric acid along with either the ferric hydroxide or basic ferric sulphate. The sulphuric acid modifies the pH in the microenvironment immediately surrounding the bacteria. If there is no external disruption, the pH frequently tends to stabilize near pH 2 due to the resolubilization of ferric hydroxide. If there is excess pyrite or pyrrhotite present, it will go lower; pH values as low as 0.9 having been attained. pH values below 1.2 have a def-

inite detrimental effect on the bacteria, interfering with their activity and resulting in the production of elongated cells.

Although T. ferrooxidans survives in conditions that are highly toxic to most other forms of life, it still must have oxygen to live. Every pound of sulphur (either as native sulphur or as sulphide) requires two pounds of oxygen for complete conversion to sulphate. Similarly, the bacteria require 0.14 pounds of oxygen for every pound of iron converted from the ferrous to the ferric form.

Phosphate and ammonia appear to be the most critical nutrients with regard to the nutrient requirement of T. ferrooxidans.

Temperature is another factor which can influence biological leaching. The optimum temperature for biological leaching has been found to be $35^{o}C$. The bacteria are inhibited at temperatures of $40^{o}C$ and above. When no other factors have become rate controlling, the rate of leaching decreases as the temperature decreases; as yet, however, no minimum temperature has been established. Leaching is known to occur slowly at $3^{o}C$ to $6^{o}C$.

Substrates Oxidized by Thiobacillus Ferrooxidans

Substrate		End Product
Ferrous Iron	Fe^{++}	Fe^{+++}
Trithionate	$S_3O_6^{=}$	$SO_4^{=}$
Tetrathionate	$S_4O_6^{=}$	$SO_4^{=}$
Thiosulphate	$S_2O_3^{=}$	$SO_4^{=}$
Sulphur	S^{o}	$SO_4^{=}$
Sulphide	$S^{=}$	$SO_4^{=}$

Metallic Sulphides Known to be Oxidized by Thiobacillus Ferrooxidans

Arsenopyrite - $Fe_2As_2S_2$	Millerite - NiS
Bornite - Cu_5FeS_4	Molybdenite - MoS_2
Bravoite - $(Ni, Fe)S_2$	Orpiment - As_2S_3
Chalcocite - Cu_2S	Pyrite - FeS_2
Chalcopyrite - $CuFeS_2$	Pyrrhotite - Fe_7S_8
Cobaltite - CoAsS	Sphalerite - ZnS
Covellite - CuS	Stannite - Cu_2FeSnS_4
Enargite - $Cu_3(As, Sb)S_4$	Tetrahedrite - $Cu_8Sb_2S_7$
Marcasite - FeS_2	Violarite - $(Ni, Fe)_3S_4$
Marmatite - (Zn, Fe)S	

The Reaction of Non-Sulphide Minerals Under Acid Mine Drainage Conditions

The decomposition of sulphides in a tailings area frequently creates chemical conditions that adversely affect the stability of many of the non-sulphide mineral species that are present. Although these non-sulphide minerals are, in general, characterized by their relative stability in a natural environment, they do break down very slowly and release anions and cations that help to make up natural background concentrations. In a tailings basin, the enormous overall surface area of the tailings mass itself is such that the slow breakdown of the various non-sulphide minerals becomes significant since the soluble reaction products frequently end up in a concentrated form in the seepage or decant overflow from the area. A few grams of tailings taken from almost any disposal area will contain at least traces of most of the elements known to man. It is for this reason that strict attention must be paid to the type and reactivity of all minerals that occur in or are associated with an orebody. As an example, consider the rocks known as granite and diabase. Both occur commonly in and around ore bodies. Granite is essentially composed of feldspar

and quartz. Minor constituents may include muscovite, biotite, hornblende and, rarely, pyroxene. Diabase is essentially a mixture of feldspar and pyroxene. Table I, presented at the end of this paper, indicates the relative amounts of the various elements that could be released if total decomposition of granite and diabase took place.

If complete treatment is not provided, an exposed tailings area, particularly if it is subject to an acid mine drainage situation, will permit the escape of many unwanted materials into our natural aqueous environment.

Revegetation

The revegetation of abandoned mine tailings in the Province of Ontario is now mandatory under the provisions of The Mining Act.

The presence of a well-developed cover of vegetation reduces the effects of acid mine drainage by regulating the effect of natural precipitation and thereby reducing the volume of acid seepage flows. However, a vegetative cover does not completely eliminate seepage flows and, as a result, some form of chemical treatment of waste flows is generally still required.

The revegetation of tailings areas that contain quantities of the iron sulphide minerals is difficult and expensive. The main problem is the acid condition that is generated by the slow decomposition of the sulphide minerals. The 'acid' that is produced must be neutralized before any seeding of the area is attempted. In addition, a large reserve of residual alkalinity must be provided so that 'alkalinity' is available on a continuous basis. The iron sulphides spontaneously produce acid and, if this is not neutralized as it is formed, a 'kill' of any established vegetation could take place. However, it is probable that, once a cover of vegetation has been established, naturally introduced acid tolerant species of vegetation will take over.

The initial neutralization of the upper few inches of an acid tailings area prior to seeding can be accomplished with powdered lime or finely-divided limestone or a mixture of both. The residual alkalinity

should be attained and maintained with a graded limestone product.

Limestone tends to be quite expensive in the mining districts of Ontario simply because the mining camps are frequently to be found considerable distances from the limestone producing centres in southern Ontario.

It should be emphasized that the limestone required for maintaining alkalinity in the upper layers of a pyritic tailings area need not be pure. Quite often the limestone can be found in sedimentary strata, sedimentary outliers, or metamorphic equivalents of carbonate sediments within a reasonable trucking distance of the mining operations. Gravel deposits that have been derived by glaciation from the aforementioned often contain significant quantities of carbonate pebbles. Pit-run or screened gravel is much cheaper than crushed limestone.

Water Recirculation

When mining activities began in the Province over one hundred years ago, there was little apparent need for strict water conservation. Today, the awareness and demands of a rapidly increasing population have changed the picture dramatically. Even the most remote mining operation is now subject to stringent environmental controls.

Wastewater re-use is a very effective way to lessen the impact of a mining operation on its immediate environment. By reducing the total volume of waste discharged from any particular operation, water recycle permits several mining companies to exist with some degree of environmental compatibility on a single lake, single watercourse, or single watershed. This sharing of a restricted area is the rule rather than the exception in the mining industry.

The most effective way to minimize an overall acid mine drainage problem during the years of conventional mine-mill operations is to reduce the total volume of effluent that leaves the property. The most convenient way to reduce the total volume of effluent leaving the property is to set up the mine-mill complex on the basis of total or at least partial water recircula-

tion.

Total recirculation in many sections of the mining industry is not easy to attain. Flotation circuits, for instance, are noted for their sensitivity. Even the simple re-use of underground (or open pit) mine water in the grinding bay of a mill that employs normal froth flotation circuits can theoretically cause problems if the water contains significant quantities of organic materials such as oil. The occurrence of trace quantities of oily materials in underground mine water as a result of mining operations is not only possible but is probable. The recirculation of a tailings area decant involves even more. The tailings area decant can and often does contain residual quantities of the more persistent milling reagents. If the decant is indiscriminately recirculated to the mill, the mill operator can lose partial control of the flotation process with the result that valuable concentrate is lost. Similarly, abnormal quantities of soluble and suspended materials that are reintroduced into a mine-mill circuit have a potential ability to adversely affect basic operations such as ion exchange, thickening, filtration, precipitation and pH control. When all of this is added to the fact that most underground mines naturally "make" more water than can be used in underground mining operations and the fact that natural precipitation on a tailings area frequently creates a significant oversupply of water as far as recirculation from a tailings area decant to a mill is concerned, it becomes obvious that total recycle is often impossible to achieve. However, partial recycle is possible in nearly every case.

All new mine-mill complexes coming into production in the Province of Ontario are currently being requested to set up their mine-mill operations on the basis of maximum possible water re-use. In existing problem areas, mining operations are also being requested to effect maximum possible water re-use.

Summary

Acid mine drainage is one of the greatest single environmental problems facing the sulphide mining industry in Ontario today. Quick and intelligent action is required. A parallel can be drawn to the mining districts of the eastern United States where neglect of the

problem of acid mine drainage has led to the impairment of over 10,000 miles of previously unaffected watercourses.

The industrial wastes program in Ontario contains the ingredients necessary to adequately control the major aspects of any acid mine drainage problem. However, complete control will be won only through the concerted efforts of government agencies coupled with the absolute cooperation of the industries involved.

TABLE I

The Average Amounts of the Elements in Crustal Rocks in Parts Per Million

(omitting the rare gases and the short-lived radioactive elements)

Atomic Number	Element	Crustal Average	Granite	Diabase
1	H	1,400	400	600
3	Li	20	24	12
4	Be	2.8	3	0.8
5	B	10	2	17
6	C	200	200	100
7	N	20	8	14
8	O	466,000	485,000	449,000
9	F	625	700	250
11	Na	28,300	24,600	15,400
12	Mg	20,900	2,400	39,900
13	Al	81,300	74,300	78,600
14	Si	277,200	339,600	246,100
15	P	1,050	390	650
16	S	260	175	135
17	Cl	130	50	
19	K	25,900	45,100	5,300
20	Ca	36,300	9,900	78,300
21	Sc	22	3	34
22	Ti	4,400	1,500	6,400
23	V	135	16	240
24	Cr	100	22	120
25	Mn	950	230	1,320
26	Fe	50,000	13,700	77,600
27	Co	25	2.4	50

Atomic Number	Element	Crustal Average	Granite	Diabase
28	Ni	75	2	78
29	Cu	55	13	110
30	Zn	70	45	82
31	Ga	15	18	16
32	Ge	1.5	1.0	1.6
33	As	1.8	0.8	2.2
34	Se	0.05		
35	Br	2.5	0.5	0.5
37	Rb	90	220	22
38	Sr	375	250	180
39	Y	33	13	25
40	Zr	165	210	100
41	Nb	20	20	10
42	Mo	1.5	7	0.05
44	Ru	0.01		
45	Rh	0.005		
46	Pd	0.01	0.01	0.02
47	Ag	0.07	0.04	0.06
48	Cd	0.2	0.06	0.3
49	In	0.1	0.03	0.08
50	Sn	2	4	3
51	Sb	0.2	0.4	1.1
52	Te	0.01		
53	I	0.5		
55	Cs	3	1.5	1.1
56	Ba	425	1,220	180
57	La	30	120	30
58	Ce	60	230	30
59	Pr	8.2	20	2

Atomic Number	Element	Crustal Average	Granite	Diabase
60	Nd	28	55	15
62	Sm	6.0	11	5
63	Eu	1.2	1.0	1.1
64	Gd	5.4	5	4
65	Tb	0.9	1.1	0.6
66	Dy	3.0	2	4
67	Ho	1.2	0.5	1.3
68	Er	2.8	2	3
69	Tm	0.5	0.2	0.3
70	Yb	3.4	1	3
71	Lu	0.5	0.1	0.3
72	Hf	3	5.2	1.5
73	Ta	2	1.6	0.7
74	W	1.5	0.4	0.45
75	Re	0.001	0.0006	0.0004
76	Os	0.005	0.0001	0.0004
77	Ir	0.001	0.006	
78	Pt	0.01	0.008	0.009
79	Au	0.004	0.002	0.005
80	Hg	0.08	0.2	0.2
81	Tl	0.5	1.3	0.13
82	Pb	13	49	8
83	Bi	0.2	0.1	0.2
90	Th	7.2	52	2.4
92	U	1.8	3.7	0.52

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"WATER QUALITY MONITORING AT THE SITE OF A PROPOSED NICKEL MINING-MILLING COMPLEX IN ONTARIO"

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1. INTRODUCTION

The International Nickel Company of Canada Limited has under development a mining and ore concentration complex in Hagey Township, Thunder Bay District, Ontario. The site is located in the Southwest Bay area of Lower Shebandowan Lake. (Figure 1).

The mine headframe and service buildings will be located on the south shore of Lower Shebandowan Lake at #2 shaft with a ventilation intake located on the northern shore of Southwest Bay at #1 shaft. Ore will be mined at the rate of 2,900 tons per day, based on a five day week. Fill method mining will be employed; all ore removed will be replaced with cemented backfill to ensure the structural integrity of the mine. Ore will be hoisted at #2 shaft and conveyed to the mill by underground conveyor.

Mining operations at Shebandowan produce two distinct liquid wastes for treatment and disposal: water from the underground mining operations, and sanitary wastes. The mine water will be treated in the underground workings utilizing a complete water treatment plant, including chemical feeders, clarifiers, vacuum filters and clear wells. This highly effective treatment developed by International Nickel Company has been reported upon elsewhere (1). Treated water will be discharged from underground and piped via a mile long forcemain to the head waters of an adjacent creek. Domestic waters, as proposed, will be collected and pumped to a stabilization lagoon. The effluent will be discharged to the tailings area for re-circulation back to the concentrator.

The mined ore will be processed in a concentrator located approximately one half mile south of #2 shaft. Ore will be subjected to crushing and grinding, followed by flotation, to separate the sulphide minerals from the rock. The mineral concentrate will be thickened and dried for shipment to Copper Cliff Smelter for further treatment. The waste rock or tailings will flow to a sand fill plant located within the mill where the coarse fraction will be removed and mixed with cement for underground backfill operations.

The fines portion of the waste rock will be pumped to a tailings area located one mile east of the mill. The tailings pond will hold all tailings water for repumping back to the mill for re-use. The mill will operate in closed-circuit with the tailings area thus eliminating any effluent from the ore concentration operations.

The Shebandowan operations have been designed to protect the aquatic environment from adverse effects due to the discharge of wastes. For example, a closed-circuit water system is being provided for the milling process. Decant from the tailings area will be returned to the mill. It has been agreed that there will be no discharge to Lake Shebandowan. As further evidence of the desire to ensure that no harm is done to the environment or to those who utilize the environment, the Environmental Science Division of James F. MacLaren Limited were authorized to carry out a water quality monitoring programme to record the quality of the aquatic environment. The objective of the programme is to measure the existing "base-line" condition of the aquatic environment before the mining and ore concentration complex becomes fully operational, and to continue such monitoring after the commencement of operations. Thus any change in water quality due to mining activities can be rapidly identified and immediate remedial action can be taken before serious

or permanent damage is caused. The monitoring programme was initiated in 1969.

The purpose of this presentation is to describe the philosophy behind the monitoring programme, its principal characteristics and the interpretation of the data collected

2. SITE DESCRIPTION

The site of the proposed mining and milling complex is approximately 50 miles North West of Thunder Bay in terrain typical of the Pre Cambrian Shield. The area is mainly bush with the occasional rock out-crop.

The major drainage basin in the region is that which drains to the Shebandowan Lake system. In general, water moves from west to east through the Lake system overflowing from Lower Shebandowan Lake into the Shebandowan River and ultimately into Lake Superior (Figure 2). Close to the proposed tailings area a small creek originates, eventually finding its way to the Matawin River and the Shebandowan drainage system. This creek is called Gold Creek and the downstream system has been called the Gold Creek - Matawin River system for purposes of the programme.

The principal uses of the lake waters and streams in the area are recreational in nature and are enjoyed by tourists, and residents of several cottages located mainly along the north shore of Lower Shebandowan Lake. Their recreational pursuits include swimming, water skiing, boating, fishing and other such activities.

3. THE MONITORING PROGRAMME

The programme comprised the following major features which will be described in turn: definition of the objective; selection of the parameters to be measured; selection of sampling points; sampling procedures; analytical methods.

3.1 Definition of Objective

It is vitally important to define the objective(s) of a water quality study prior to initiating data collection. Many factors are involved with the design of a programme among which are the parameters to be measured, the frequency of sampling and the number of sampling stations to be used. There are many possible combinations. However, most studies have limits imposed on them by such factors as climate, accessibility, budget and time schedule and the combinations selected must be the most useful in achieving the objective. It is therefore essential to have a complete understanding of the objective(s) if it is to be achieved within the specified limits.

As described previously the objective of the Shebandowan water quality monitoring programme is to establish a base-line record of water quality by which future changes due to industrial operations can be identified if they occur.

3.2 Selection of parameters to be measured

3.2.1 Physical

The physical characteristics of bodies of water fall readily into two categories; those of a morphometric nature such as water surface area, depth, shore length water levels and geology, and those which directly reflect the actual quality of the water at the time of measurement such as water flow rate, temperature and turbidity. Although valuable information for predicting water quality can be gained from morphometric measurements they were not essential to a base-line quality monitoring programme.

Temperature is a highly significant parameter as it affects lake stratification, the solubility of many substances and the numbers and distribution of biological species in the body of water.

The significance of turbidity relates primarily to the penetration of light in the water body which in turn controls the growth of photo-synthetic organisms such as plankton and rooted aquatics. This is the beginning of a long chain of interrelationships affecting the numbers and species of higher organisms which can be supported by the phytoplankton and the physical and chemical quality of the water.

A parameter which tends to affect the quality of the water more in streams than lakes is that of water movement. In streams the ecosystem, or relationship between physical, chemical and biological parameters, is highly dependent upon the flow in the stream. The flow characteristics which are determined by drainage area, season, stream slope, roughness of stream bed etc. and which in turn determine the temperature of the water, reaeration characteristics and other quality parameters is an essential measurement if differences in water quality measured at different times are to be explained. In lakes, changes in water movement also affect the ecosystem but to a lesser extent because the volume of water tends to damp out significant changes.

In this programme the physical parameters measured were temperature, turbidity, depth and water flow rate when and where possible. Flow measurements were made by surveying stream cross sections at the stations, measuring the depth of water and its velocity. Table 1 shows a selected list of physical, chemical and biological water quality parameters used in monitoring studies.

3.2.2 Chemical

Chemical parameters to be monitored were selected to enable future identification of changes in water quality as being caused by the mining and milling process or by natural causes.

Conductivity or specific conductance measures the ability of the water to conduct an electrical current which ability is in turn dependent upon the concentration of dissociated salts in solution. The measurement may therefore be used to identify the discharge of wastes bearing high concentrations of dissolved solids. The value of conductivity measurements lies in their simplicity and ease of determination with portable equipment in the field (2).

Alkalinity, pH and the forms of hardness are highly interdependent parameters which depend upon the carbonate-bicarbonate-carbon dioxide balance in natural waters. Changes in their values may be observed in relation to season, biological productivity and, in stratified lakes, sample depth. However, in a given system a pattern of change is frequently established which can be altered radically over a short period of time only by man's actions.

Colour in water bodies frequently is derived from compounds leached from decaying vegetation. The significance of this parameter is somewhat limited except that certain industrial waste discharges may either colour or decolourize water because of the organic and inorganic compounds they contain.

An important parameter in any water quality monitoring study is dissolved oxygen upon which normally desirable forms of biological life are dependent. Its significance is highest when considering the possible discharge of organic wastes to water bodies. Considering the nature of the waste from the mining and milling complex,

which was expected to be almost devoid of organic matter, the measurement of dissolved oxygen was included to characterize the aquatic environment.

Nitrogen and phosphorus, nutrients essential to the maintenance and increase of biological productivity in a water body, were monitored to determine the existing and potential productivity of the waters.

The remaining chemical parameters measured were copper, nickel, zinc and iron concentrations, elements which might be expected in the effluents from the mining and milling operations. All of the foregoing elements if present in sufficient concentration may cause undesirable effects in water bodies.

3.2.3 Biological

There are marked disadvantages about establishing base line water quality conditions using physical and chemical parameters only. In many cases the change in chemical or physical characteristics of a water body are not in themselves significant especially if the changes are small. However, the uses of the waters are frequently based upon the nature of the biological life in the water body which may be changed drastically by seemingly insignificant changes in physical and chemical quality. It is thus considered essential in all water quality monitoring programmes to achieve an appreciation of the biological system.

Additional reasons supporting the need for biological considerations relate principally to streams. The physical and chemical characteristics of a stream at a sampling station can change rapidly because the flushing action of the stream changes the water continuously at the station. Unless continuous monitoring is available, changes which may be due to transient pollution, fluctuating flows in the stream etc. may not be recorded. Similarly slight changes in water quality involving toxic or other materials may not be readily identifiable by chemical analysis, assuming sufficient knowledge is available to know what may be present in the water. In both of these cases an analysis of the biological communities in the river both of the water and the bed materials may produce much valuable information on the history and effect of constituents of the river water.

The biological parameters which should be measured to give a sound appreciation of the water quality in a body of water have been the subject of much debate. Formalized systems classifying organisms according to water quality have been proposed which, like many formalized systems dealing with nature, apply only in a minority of situations. Hynes (3) indicates that all categories of living creatures are useful in establishing water quality and that investigations should use all the methods which are feasible under the prevailing conditions. In this monitoring programme type, variety and number of phytoplankton and benthic organisms were studied. The type of bottom sediment from which the benthic organisms were obtained was also described in order to obtain a meaningful interpretation of the numbers and variety of benthic organisms present.

3.3 Selection of sampling stations

The selection of suitable sampling stations is of prime importance to the validity of data collected in a water quality monitoring programme. An ideal station would possess the following characteristics:

(a) The quality of the water sampled on a cross section at an ideal station on a stream would be the same at all points of the cross section. In a lake the quality of water samples taken at a particular depth would be the same at that depth over the area the sample is meant to represent.

(b) Accessibility is an obvious requirement and frequently governs the location of the station.

(c) As discussed previously measurement of flow, particularly in streams, is necessary for the interpretation of water quality. Consequently stations close to bridge abutments, flow control devices and regular-shaped stream cross sections where flows can be measured relatively easily are favoured.

An initial reconnaissance of the site was carried out to establish the most suitable location for sampling stations. It is recommended that this be a task with high priority in any monitoring programme. During this

survey the waters in the Southwest Bay area were examined at numerous locations and at varying depth for temperature, dissolved oxygen and electrical conductivity using portable instruments. It was found that the maximum depth in the Bay was approximately 37 feet and that there was little variation in quality throughout the area at any particular depth which could be attributed to local currents or inflows of water from the drainage system. In view of these findings, six sampling stations were selected to monitor general water quality conditions in the Bay and to detect any changes in water quality which may be due to mine operations. The stations, which were marked on site by means of fluorescent buoys anchored to the bottom of the lake, were fixed by field survey so that they could be relocated at any time if for some reason or other the buoys were to be lost. This precaution proved its worth many times when buoys were lost due to activities on the lake. The samplings of bottom fauna at these stations initially showed a relatively low number of organisms present. Consequently six further sampling stations were set up in shallower water in the vicinity of the two mine shafts for the sole purpose of monitoring bottom fauna. A further station was located at the outlet of Lake Shebandowan.

The location of sampling stations on the Gold Creek-Matawin River system was dictated largely by their accessibility. A helicopter was used to reconnoitre the area so that the most suitable sampling stations could be established. It was also used to gain access to the sampling stations at later dates. A station was established on Gold Creek just prior to the discharge on Pewatai Lake so that data could be collected which would be indicative of the ecology of this particular part of Gold Creek. Stations were also located upstream of the confluence of Gold Creek with the Matawin River and the confluence of the Matawin River with the Shebandowan River to provide information on the quality of the water entering the larger water courses. A final station was located where Highway 17 crosses the Shebandowan River because of its accessibility and because of the existence of a Department of Energy, Mines and Resources river flow gauging station at this location.

3.4 Sampling Procedures

The collection of representative samples is basic to the value which can be placed upon the results of a water quality monitoring survey. Careless sampling cannot be accounted for in any of the other steps of a programme. As such, this aspect of the work demands

that well trained sampling personnel be employed. The training requirement is not so extensive for sampling for physical and chemical quality evaluation as it is for biological sampling. In the latter case a trained biologist is frequently required to select the actual sampling station and to interpret the analytical results in light of the surrounding environment such as depth of water, velocity, nature of bed materials and degree of exposure.

Samples for physical and chemical analysis should be collected using a device which can extract a volume of water from any desired depth in the lake and bring it to the surface for analysis without changing the quality of the sample. One device frequently used, and which is used in this programme, is a Kemmerer sampler. A schematic of the sampler is shown in Standard Methods (4). The unit is also useful for obtaining water samples for phytoplankton analysis. Based on the results of the early surveys it was decided that samples for chemical and physical analysis would be taken at depths of 3 ft. from the surface and 5 ft. from the bottom of the lake so that an appreciation could be obtained of the water quality within the two principal water masses, if the lake stratified during the summer months. Phytoplankton samples were taken at depths of 3 ft. and 15 ft. from the surface.

In stream sampling, where the samples are usually taken from well mixed sections, it is usually satisfactory to obtain a sample by immersing a sample bottle about 6 inches to 1 ft. below the stream surface and allowing it to fill with water.

Samples from the lake bottom for analysis of benthic organisms were collected using an Ekman-type dredge a schematic of which also can be seen in Standard Methods. (4). The samples were sieved on site before transfer to sample bottles.

Samples for studying the fauna of streams can be collected by several alternative methods. There are disadvantages associated with all of the methods. In this study a Surber net was used.

The frequency of chemical and physical analysis was approximately once a month during those periods of the year when the waters in the area were ice free. Biological analyses were carried out once every two months during the same period. Mackenthun and Ingram (5) indicate that bodies of water in which plankton populations and chemical constituents may change rapidly should

be sampled at weekly intervals, as a minimum, throughout the season of active biological growth. Bottom fauna should be sampled during the annual seasons. In the survey at Shebandowan because of the characteristics of the waters, accessibility, and budget, it was not considered necessary or feasible to carry a more frequent sampling programme. Observations during the regular monthly visits confirmed this.

3.5 Analytical Methods

Chemical analyses were carried out, in general, by the methods described in Standard Methods (4) which includes in its text a discussion on sampling and preservation of samples. Samples for nitrogen and phosphorus determination were preserved by the addition of sulphuric acid.

All phytoplankton samples were fixed with Lugol's iodine solution on site. At the laboratory it was found necessary to concentrate the samples by centrifuge in order to obtain representative generic lists of phytoplankton. If this were not done only the most common genera were recorded and these are not necessarily good biological indications of change in environmental conditions. The algae were counted using a Sedgewick-Rafter counting cell.

Benthic samples were fixed on site and then prestained for ease in sorting. At the laboratory the samples were washed to remove extraneous material and all visible organisms were picked out for identification.

3.6 SCAN type monitoring

In a recent paper by Hawley and Shikaze (6) it is recommended that a complete analysis should be run to identify and determine the amount of every contaminant in wastes from mining and milling processes. They call this type of analysis a SCAN type analysis. It should include:

pH		
sulphates	lead	barium
acidity	vanadium	lithium
iron	cadmium	sodium
copper	mercury	potassium
zinc	tin	calcium
cobalt	titanium	aluminum
nickel	chromium	arsenic
manganese	molybdenum	phosphorus

The authors also indicate that if any heavy metal in the effluent or effluents is present in concentrations greater than 1.0 mg/l it should be considered as a potential cause of downstream environmental problems. Similarly if the total concentration of heavy metals exceeds 1.0 mg/l their combined effect may be great enough to warrant concern.

4. RESULTS OF THE MONITORING PROGRAMME

The data collected with the monitoring programme during the years 1969 - 1970 are summarized in Tables 2 and 3. As will be seen there are appreciable differences between the values obtained in 1969 and 1970 for some of the parameters. However, considering that the existing discharges to the environmental waters from the mining and milling operations are, and have been, minimal up to the present time, it is assumed that the changes shown are either due to natural change or the limits of analytical techniques. This brings forth a major argument in favour of conducting base line quality monitoring surveys prior to the start-up of a new operation. The natural variation in water quality is difficult to predict in many water systems and in order to protect not only industrial interests but also those of other water users, it is essential that the variation in natural quality be established such that this variation is not attributed to the industrial operation.

It is not intended that any further discussion of the results be given in this paper as they are only of significance to the site at Shebandowan. However, it appears to be of value to summarize the conclusions of the survey to demonstrate the type of information which can be extracted from the raw data. The conclusions reached after the first year of survey in 1969 were as follows (7):

1. The aquatic environment within the study area was found to be essentially free of inorganic pollutants. The water was soft with a low dissolved solids concentration and the components that were found to be present were considered to be, in general, of natural origin.

2. Chemical analysis has indicated that the nutrients nitrogen and phosphorus were present in concentrations the same as noted in the literature when algal blooms have been observed. However, biological examination has shown that the study area in general was only sparsely populated and that the aquatic environment had a low productivity. Thus some other nutrient(s) or some environmental condition necessary for

greater biological production must be limiting.

3. The biological flora and fauna exhibited a sufficient variety and number of pollution sensitive organisms to indicate that the aquatic environment was in a healthy condition.

4. No evidence was found to indicate that discharges from temporary waste water treatment facilities provided for the construction phase were affecting the quality of the water in the Southwest Bay area of the lake.

Conclusions from the 1970 monitoring programme were as follows (8) :

1. The monitoring programme in the study area indicates that the aquatic environment continues to be representative of a natural environment.

2. It cannot be absolutely determined how much of the nitrogen and phosphorus already present in some quantity in the lake has been contributed by local human activities. There have been cottage developments on Lake Shebandowan for some years now which may have contributed to these important elements.

3. There are no significant increases in the levels of nitrogen and phosphorus in Southwest Bay as a result of construction activities in the area. Rather, the lowest values found for these two elements occurred in the general vicinity of the two shaft sites.

4. The productivity of Lake Shebandowan does not appear to be controlled by nitrogen, phosphorus, silicon or sulphur. The limiting factor has not been determined although analysis shows that carbon sources are very low in this particular lake. Benthic fauna results continue to indicate a healthy environment in the surface sediment of the floor of the lake.

5. No increase in phytoplankton productivity has been observed in Southwest Bay. The productivity remains at a low level. From this observation it is predicted that Lake Shebandowan will not support large fish populations.

6. The monitoring programme has revealed other activities on the Gold Creek - Matawin River system which may affect the local ecology.

Following the initial two years of survey it has been found possible to reduce the scope of the monitoring programme and yet obtain sufficient information to indicate any changes in local water quality. In addition, it was recommended that additional parameters be examined, further studies be made of the Gold Creek - Matawin system to determine whether the activities of other interests operating in the area are affecting the local ecology and that productivity studies be carried out to determine the level of productivity of the lake.

5. CONCLUSIONS

With the ever increasing emphasis on maintaining our environment in a condition suitable to support existing and expected future life styles, pollution control regulations will continue to become more stringent. In recent work where the Ontario Water Resources Commission has been involved, there have been indications that the responsibility to demonstrate that discharges do not detrimentally affect the environment will lie with the potential polluter. To a large extent this latter aspect of developing government policy has been created by a realization of the complexity of the interactions between the aquatic environment and the wastes which are discharged to it. Studies to determine the interactions can be correspondingly complex and beyond the existing resources of government agencies to undertake in the case of all potential polluters. It is thus concluded that :

i) where the condition of a body of water expected to receive waste discharges is not well identified it is advisable, if possible, to define the quality of the existing aquatic environment and its natural variation. In this way not only can environmental quality protection be based upon firmly established data, thus ensuring a higher confidence in proposed protection measures, but also industry can protect its own interests. Waste treatment plants and waste disposal methods can be optimized with regard to cost and efficiency rather than providing excessive facilities at extra cost because potential effects are not known. The effect of industrial discharges will be identifiable and thus the industry cannot be blamed for something which they did not cause.

ii) the demonstration of concern for the condition of the environment by industry leads to an image of good corporate citizenship which is of value in public relations programmes.

iii) the validity of water quality monitoring surveys is highly dependent upon the selection of sampling stations, sample collection and frequency and time of sampling. Care must be exercised in designing the foregoing items into the programme.

iv) an efficient and economical programme requires the judicious selection of parameters for evaluating the quality of a water body. A biological appreciation of the aquatic environment is necessary to evaluate fully the effects of waste discharges.

v) A SCAN type of analysis is of particular value in dealing with mining and milling wastes. However, such analyses also would provide a great deal of useful information about the effects of other types of waste streams.

ACKNOWLEDGEMENTS

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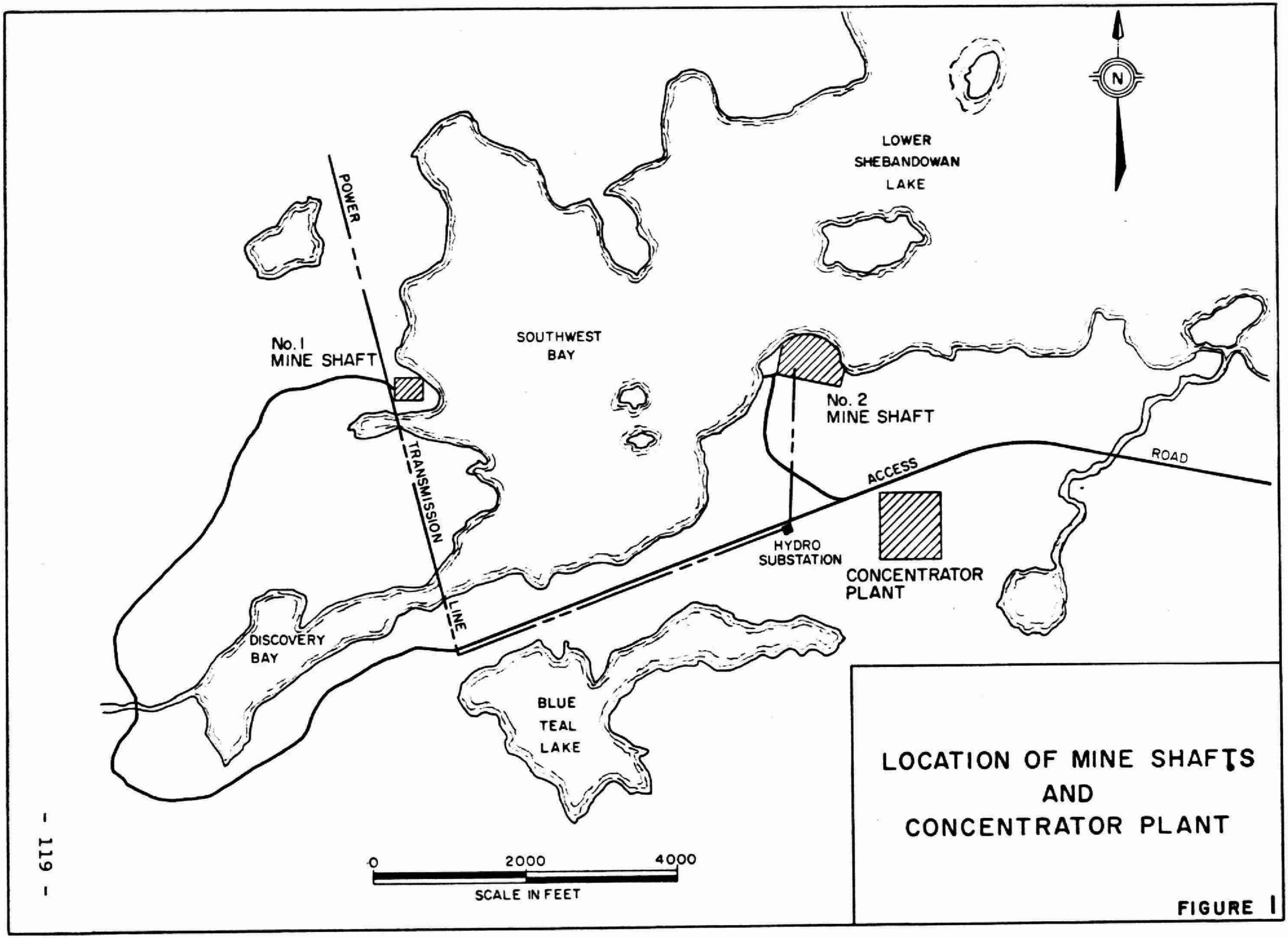
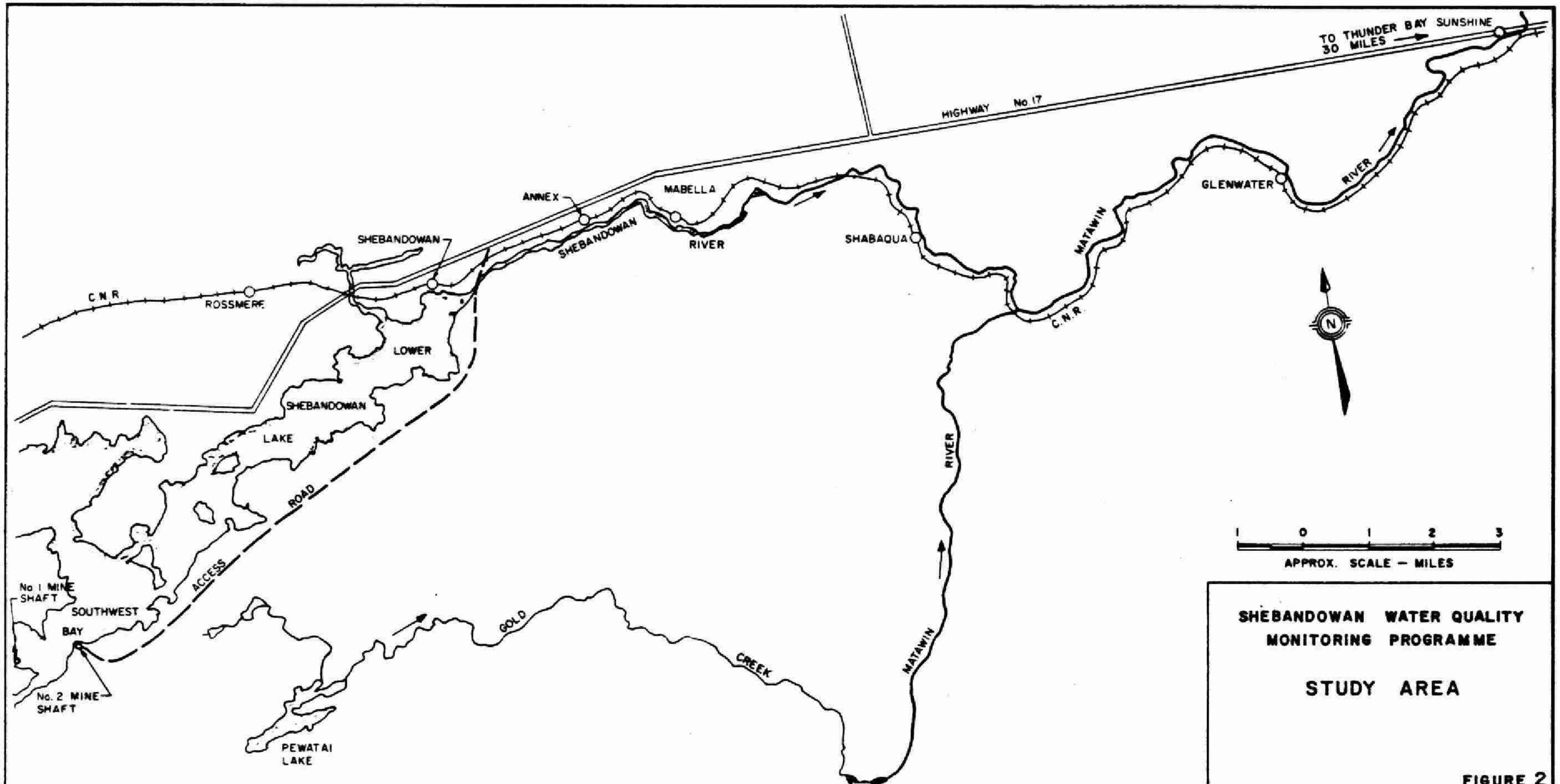


LOCATION OF MINE SHAFTS
AND
CONCENTRATOR PLANT

FIGURE 1



SHEBANDOWAN WATER QUALITY MONITORING PROGRAMME

STUDY AREA

FIGURE 2

TABLE 1

PARAMETER	INTERRELATIONSHIPS	SIGNIFICANCE
PHYSICAL		
Temperature	Depth of lake, season, flow of water, turbidity	Dissolved oxygen concentration, habitat for aquatic life, productivity
Turbidity	Flow of water, photosynthesis, waste discharges	Aesthetic, habitat for aquatic life
CHEMICAL		
Conductivity	Drainage basin characteristics, waste discharges	Identification of pollutants
Alkalinity, pH and hardness	Drainage basin characteristics, productivity, depth	Productivity and identification of pollutants
Colour	Drainage basin characteristics, waste discharge	Aesthetic, waste discharge
Dissolved Oxygen	Temperature, productivity, flow of water, depth	Habitat for aquatic life, productivity
Nitrogen and Phosphorus	Productivity, waste discharge	Productivity
Copper) Nickel) Zinc) Iron)	Drainage basin characteristics, waste discharge	Habitat for aquatic life, waste discharge, water supply
SCAN Analyses	Drainage basin characteristics, waste discharge	Habitat for aquatic life, waste discharge, water supply
BIOLOGICAL		
Phytoplankton	Physical and chemical parameters above	Productivity
Benthic Flora and Fauna	Physical and chemical parameters above	Detection of pollution, productivity

TABLE 2

SUMMARY OF DATA

PARAMETER*	LAKE STATION 1969	1970
TEMPERATURE (°C)	6.0 – 21.5	3.0 – 20.0
TURBIDITY (J.T.U.)	5 – 10	5 – 5
COLOUR (°H)	10 – 20	15 – 15
CONDUCTIVITY (μMHOS)	53 – 59	54.5 – 57.0
DISSOLVED OXYGEN	8.1 – 12.3	9.5 – 10.5
TOTAL SOLIDS	22 – 64	32 – 58
SUSPENDED SOLIDS	0 – 1	0 – 1
DISSOLVED SOLIDS	22 – 64	32 – 58
ALKALINITY	27 – 34(1)	19.0 – 20.5(2)
TOTAL HARDNESS	24 – 29	24 – 27
CHLORIDE	1.0 – 1.75	0.75 – 1.50
SULPHATE		5.5 – 7.6
TOTAL NITROGEN	0.24 – 0.37	0.209 – 0.454
TOTAL PHOSPHORUS (ppb)	8 – 19	3 – 48
TOTAL COPPER (ppb)	7 – 50	35 – 57
TOTAL NICKEL (ppb)	<8	<10
TOTAL ZINC (ppb)	14 – 60	25 – 81
TOTAL IRON	0.03 – 0.07	0.02 – 0.06

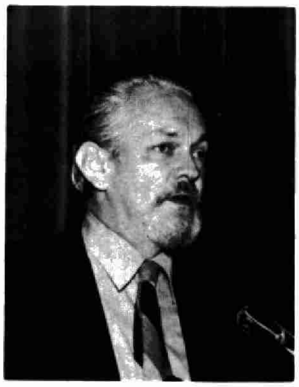
* ALL VALUES IN MG/l EXCEPT WHERE INDICATED.
(1) TO METHYL ORANGE END POINT.
(2) TO pH = 4.5 ELECTROMETRICALLY.

TABLE 3

SUMMARY OF DATA

PARAMETER*	GOLD CREEK 1969	GOLD CREEK 1970
TEMPERATURE (°C)	5.0 – 24.0	
TURBIDITY (J.T.U.)	15 – 45	25 – 40
COLOUR (°H)	80 – 140	50 – 140
CONDUCTIVITY (μMHOS)	60 – 132	69 – 145
DISSOLVED OXYGEN	7.0 – 14.0	8.8 – 10.8
TOTAL SOLIDS	53 – 100	106 – 136
SUSPENDED SOLIDS	0 – 9	1 – 10
DISSOLVED SOLIDS	46 – 100	104 – 135
ALKALINITY	39.0 – 84.5(1)	27.5 – 68.5(2)
TOTAL HARDNESS	29.5 – 73.0	42.5 – 70.0
CHLORIDE	0.75 – 1.50	0.5 – 1.50
SULPHATE		6.1 – 11.9
TOTAL NITROGEN	0.56 – 0.97	0.455 – 0.840
TOTAL PHOSPHORUS (ppb)	35 – 61	38 – 108
TOTAL COPPER (ppb)	7 – 30	14 – 25
TOTAL NICKEL (ppb)	<9	<10
TOTAL ZINC (ppb)	7 – 24	10 – 44
TOTAL IRON	0.48 – 1.17	0.24 – 0.94

* ALL VALUES IN MG/l EXCEPT WHERE INDICATED.
(1) TO METHYL ORANGE END POINT.
(2) TO pH = 4.5 ELECTROMETRICALLY.



D.A. Chant

"THE ROLE OF PUBLIC PRESSURE GROUPS IN ENVIRONMENTAL CONTROL"

BY

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I would like, first of all, to say a word of compliment to you on holding your 18th Industrial Waste Conference. I think that's quite a measure of achievement and it indicates that a lot of the current public concern over our environment has been going on, perhaps in more quiet ways, over quite a long period of time. I would also like to say how much I appreciate the opportunity to speak to you today on the topic of public pressure groups and their role in environmental control. There is a lot of misunderstanding on the part of people in government and industry as to exactly what function these groups are playing in our society today, and I hope that some of my remarks this morning will be of interest, and informative to you. It is a little unfortunate that the word "pressure" has been used in the title of my paper. I did not choose it and it indicates a certain prejudgement and state of mind with regard to the role of citizen groups and environmental quality. I hope to show that pressure is only one of a number of what I conceive to be very important roles being played today by these, I prefer the word, citizens' groups.

You all know, I think, that over the last few years there has been a tremendous upsurge of public participation in many problem areas that confront our society. We have seen citizen groups come together for many purposes - groups on international [illegible]ms, groups on problems of our native peoples, on taxation

problems, on economic problems, on ratepayers' problems, on just about every sphere of our activity. Last year the CBC even considered doing a program on "The Year of the Citizen" because it was felt that this sort of citizen participation was a new phenomenon, and one that should attract a considerable amount of attention.

In the area of environmental quality, or environmental control, or pollution, or whatever term you prefer to use, you are also aware that a large number of groups has sprung up over the last two or three years. Pollution Probe at the University of Toronto was one of the first - but by no means <u>the</u> first - and it has proliferated across the country until there are about fifty chapters of Pollution Probe now, from Regina to Halifax. Groups in the West have sprung up, mostly associated with the Society for Pollution and Environmental Control (SPEC) centred in Vancouver. There is the Committee of a Thousand, which has been very active here in the Niagara Peninsula. There are now groups in Montreal, in Ottawa, and Quebec City, really in every centre of population across Canada, and last year these groups finally began to come together to form a national organization called The Canadian Association on the Human Environment. The CAHE has a federal charter and its primary purpose is the exchange of information and the coordination between groups across the country on matters of common interest. Many people have wondered publicly whether this tremendous surge of public concern, public awareness, is going to fade away as quickly as it arose. It is true that the attention span of our species for any particular problem is remarkably short. We seem to get terribly concerned about some particular issue and then, lo and behold, in a few weeks or a few months we have flitted on to something else. I do not want to examine in depth what I think are some of the reasons for this. You will have your opinions and I have mine and they are probably quite similar, but I do feel that in the area of environmental quality there are a few elements that are not present in some of these other fads that have attracted our attention - such as the Biafra situation of two years ago. Who reads anything about Biafra in the newspapers today? The major element, I think, is that our concern over pollution is not just an intellectual or emotional exercise. It is not something that one is just exposed to through the media, that you can come home at night and spend your half-hour worrying about, then have another beer and forget all about. Pollution is with us in a very visible, sensual way. All you have to do is open the door or look out the window and you know that the quality of our environment is not all it should be. So I feel that this, perhaps more than

anything else, will tend to guarantee that our present concern, this wave of public participation, is not something that will just disappear overnight. I do not mean to be too critical, because the media generally have played a very vital and dynamic role in this issue of environmental control - but some elements of the media today are beginning to make a fad out of asking if public concern over pollution is, itself, a fad. Some elements of the media now seem more interested in highlighting public apathy to environmental problems and those who criticize anti-pollution groups, than they were last year when the shoe was on the other foot, and anti-pollution groups were getting all the publicity. There has been a lot of publicity recently over the fact that a relatively small percentage of housewives are deliberately shopping for low phosphate detergents, and there has been some publicity over the fact that some people are wondering whether we shouldn't be moving back to the hard organo-chlorine pesticides because we're getting bitten by a few more mosquitoes than we're used to in our recreational and resort areas. Well, this is alright and I think it tends to create a better balance than last year when everything was going in favour of the anti-pollution groups.

The growth of citizen groups in the environmental sphere dates from about three years ago, as I mentioned. There are many other organizations concerned with the environment in a very broad way that have a long and illustrious history. The Conservation Council of Ontario, for example, goes back quite a long way, as do the Audubon Society, the Canadian Wildlife Federation, and the Federation of Ontario Naturalists. All of these groups have a long history, but until very recently they were not militant in any sense of the word and one could hardly say that their primary interest was in pollution control or environmental quality control. Therefore, they, too, only in the last two or three years have begun to develop this new direction for themselves and this new relevance.

The development of these citizen groups in this very recent period of time stemmed from a number of rather obvious causes, the first of which is frustration. Most of us - regardless of what issue - have at times a sense that the system has become too big, it has insulated itself from, and tends to neglect, the concerns of the individual citizen. This tends to make us quite frustrated. We see this in all areas of concern, not just in the area of environmental concern. This sense of frustration, this sense of not being a part of the system anymore, of not being able to exercise an influence on the system anymore, led people to

realize that, as individuals, they indeed had very little power at all. Therefore, many people felt that they had to come together, they had to exercise whatever influence they had, whatever power they had, in the form of groups rather than as isolated, uncoordinated, unrelated individuals.

The second reason for this tremendous upsurge in public concern is the demonstrable, increasing intensity of the environmental problem. It is true that with some kinds of pollution control we have made advances to the point where they are better now than they were, say, a decade or two decades ago; but in other areas of environmental quality, we have not been able to bring about any measurable restoration or improvement of environmental quality. This is particularly obvious to people who live in urban centres, where they are subjected to the increased intensity of noise and congestion, both of which are measurable elements of environmental quality and have a direct and emotional impact on the individual. They also see in their recreational areas that the quality of the water is not what it used to be, and the lakes themselves are becoming congested and, at times, overrun with motorboats. They have great difficulty in even getting to and from the holiday areas that used to be so peaceful and so pleasant. I don't know how many of you try to struggle up Highway 400 to the Muskoka area every Friday night, and fight all the way back every Sunday night, but if there are any of those people here, they will know abundantly what I am talking about.

A third element in the growth of citizen groups has been improved communication and the very legitimate attention that the media have given to environmental problems. This has given the people with concern across Canada a sense of community; they know that there are people in other population centres across the country who share their concern and they have some means of communicating one with another, and of banding together to exercise whatever influence they can.

And, finally, and this is perhaps not a very good reason - our society is pretty well off. We have increased wealth and leisure time, which frees us to spend our time on trying to improve environmental quality, and trying to solve other problems that confront us. This has enabled us to put a much higher emphasis on the quality of the environment in which we live, on the quality of our lives, than people are able to do in less fortunate countries. We are all aware that in some developing countries there is a degree

of envy of Canada and the United States and other developed countries because of the degree of pollution we are able to create. This is a measure of our success in a technological, materialistic world, and because of this success - this undeniable success - we now are able to emphasize life quality, we are able to spend the time and the effort to improve the quality of our environment.

The roles that these citizen groups have played and should play in our society is what I was really asked to talk to you about today. The first role - and these are not necessarily in order of importance or in order of priority - is that these citizen groups provide opportunities for anyone and everyone to participate in the whole area of environmental control, and by that simple act of participation, of belonging to a group with discreet, well-identified objectives, the individual is relieved of some of the frustration that I mentioned earlier. There is nothing like direct, active participation to relieve one of a sense of helplessness, and a sense of frustration in the face of bigness and a relatively inert system. It doesn't really matter how active or how major a part many of these citizens play in their groups, it is the fact that they are there at all that tends to relieve this frustration.

Secondly, citizen groups permit people to demonstrate their concern. Individual acts in trying to control environmental quality really count for very little. I disagree very strongly with the present tendency of some government agencies and industries to say that pollution control is up to the individual. That is absolute and complete nonsense. There is no other area of major public concern where we as individual citizens are expected to find, develop and impose solutions. I am not asked as an individual to solve Canada's international problems, I am not asked as an individual to solve Canada's economic problems or agriculture problems, or to solve the egg war with the Province of Quebec. We expect our government systems to recognize and identify major problem areas and, in an institutional way, to do something about them. The same thing is most emphatically true with pollution control. However, individual acts - restraining oneself from throwing a kleenex out of the car window or breaking a beer bottle on a beach, or using a low-phosphate detergent - do have a value, and the value is that of commitment and dedication. By exercising discipline over oneself and one's family and friends, one can show that one is concerned with environmental quality. It is somewhat the same as the act of dedication involved in going to church on Sunday mornings. You are demonstrating your concern, you are

showing that you are dedicated. The citizen groups permit people to do this and I think they have a real value for that reason.

The third role - and perhaps the most major role of all - of citizen groups in environmental quality is the educational role. I personally feel that the ultimate solution to our environmental problems is not laws, it's not legislation, it's not fines, it's not bans - although those may have temporary value - but rather it is education, and the citizen groups have a major role to play. The individual who joins a citizens' group dedicates himself to its purposes, and becomes better informed on environmental problems through group activities. Most citizen groups put on short courses for their membership. They have newsletters that disseminate information that makes the individual member better informed about environmental quality. The group itself usually has educational programs in the community at large, in addition to its self-education. They go out into the community, into the schools, and they use the media to aim information to society as a whole. You might be interested to know, for example, that Pollution Probe at the University of Toronto, which regards its educational program as the most important thing it does, spoke to over a hundred thousand schoolchildren in the primary and secondary schools in the Metro Toronto area last year. This is a remarkable achievement and clearly highlights what, to me, is one of the most important things we can do.

Fourthly, citizen groups have a role to play in the political process. They have an opportunity of presenting issues to political parties for their reaction and, hopefully, eventually to be assimilated by the parties and worked into their policy platforms. They also have a role to play in presenting issues to individual candidates of whatever party to encourage an open and complete public discussion of pollution. I can give you two examples of how these things have worked for Pollution Probe in the past, to demonstrate clearly what I mean by taking part in the political process. First of all, Pollution Probe, at the time of the leadership contest for the Progressive Conservative Party of Ontario last February, developed a questionnaire with ten questions on future policies and attitudes towards environmental problems. The five major candidates for the leadership were very cooperative and they filled out these questionnaires - often with extensive additional comment. Probe proceeded to rate the candidates on this basis. We had good cooperation from the media and it attracted quite a lot of attention. That was a positive contribution to, and direct participation in, the political process. We will do it again when the leadership of other parties is being contested.

The second example is that when the next provincial election comes along, whenever that may be, Pollution Probe groups across Ontario plan to send questionnaires to all major candidates regardless of their party - both to stimulate comment and debate at local party meetings and also eventually to rate candidates on the basis of their environmental awareness. I must interject here that we know and understand that environmental awareness is only one of the major areas of awareness that any candidate must have and I do not want to suggest that a person should necessarily stand or fall on his environmental sophistication or his environmental ignorance. But we do feel that it is a major factor that should be considered by the voting citizen when, in the privacy of his own mind, he is trying to decide for whom he will vote.

Citizen groups in the pollution field are often accused of being, themselves, a political movement. This is becoming increasingly true in the United States, where there is talk of forming an ecological, environmental political party. Many people automatically label the environmentalists as being on the left - even on the far left - and it has even reached the point in the United States where a person can very genuinely stand up and say "I'm against ecology because ecology has taken to itself such a clear and overt political label". I think we have to avoid this in Canada. All political parties must have environmental concern, environmental awareness, and for citizen groups to ally themselves to any political party would be the kiss of death. I do not think there is any need for this, and it would be self-defeating. I like to say that we will pat any political party on the back if it does something good, and we will kick any political party in the teeth if it does something bad, without bias, prejudice or favouritism.

Another role of the citizen groups, and this is the one implied by the title of my talk today, is to exert pressure on government and industry. Many of us feel that there is a lot of inertia in our system, and that this has to be overcome by the application of pressure. We feel that in some instances, particularly in the recent past, heavy pressure has been required to get effective action. Also, many of us feel that there are counter-pressures that are being exerted on the decision-making centres of government. Often these are subtle, and not in the public eye, but these pressures are there and public pressure - pressure from citizen groups - has to be applied to counterbalance them. Moreover, by exerting pressure on government, we feel that this helps to bring our democratic system to a point where it can operate the way it really should. In our system - and I think it's the best system, I think it's the only alternative

- the decison-makers have to know what the public really wants and overt pressure from public groups is one of the most effective ways of demonstrating this, of showing our decision-makers what, indeed, it is that the uncommitted member of society wants and of bringing this information to his attention so that it's part of the equation in his mind when he finally decides what course of action he is going to follow.

There are certain dangers inherent in the operation of citizen groups, particularly in the environmental field, and I would like to outline some of these dangers, in addition to what I have said about the important roles that I think they can play. The first and most obvious danger is that of error. No citizen group can be fully expert on all aspects of environmental problems. None of you is, none of the agencies that you represent is, and, of course, it would be ridiculous for a citizen group to pretend to be, or to be labelled as, completely expert in the whole array of problems. Sometimes the enthusiasm and the concern of the citizen group runs ahead of the facts and the knowledge that it has. Sometimes this running ahead is the result of government secrecy, and frequently the target of the group should be not to insist on a ban, or the passing of some sort of law, but first of all to insist that all reasonable information that is available through government research agencies should become public property. Only if that were done, would it be possible for the citizen group to make a rational decision as to its course of action on the basis of the best and fullest knowledge available. So sometimes I think groups let enthusiasm run away with them, and sometimes they choose the wrong target. However, this sort of thing should be tolerated more than it is. One of the commonest criticisms of those who are the targets of citizen action groups, or who just plain disapprove of that form of participation, is to suggest that groups do not know what they are talking about, and to try and erode their credibility. This is unfortunate, and one should give the citizen groups the benefit of the doubt. To me, the enthusiasm and the concern are greatly more important and impressive than whether or not they can dot each "i" and cross each "t" in a highly technological area of concern.

Secondly, citizen groups often tend to oversimplify. They demand instant solutions when, in fact, solutions are almost always incredibly complicated. This, too, is a consequence of their concern and their enthusiasm, and I think rather than for the targets of this kind of pressure to withdraw completely into a defensive shell and say "you're a bunch of idiots", it would be better to establish some sort of dialogue between the two poles so that the citizen groups can be led to understand that one cannot

wave a magic wand overnight in the legislature and suddenly solve all our environmental problems. Frequently when I give talks to public groups, people will come up afterwards - particularly young people - and say "why don't we stop polluting the environment", why don't we do this and why don't we do that, not realizing that the answer does not lie in some gigantic plot to destroy our environment. Often it is not because of lack of interest, it is because our system genuinely does not know what to do. We do not have effective solutions worked out for many of our environmental problems, particularly some of the more basic ones. So bear with citizen groups if they oversimplify, bear with them if they commit errors of fact at times, and give them full credit for their enthusiasm and their concern.

The third danger of citizen groups is faddism. These citizen groups, because they get media attention, at times attract people who are sensation-seekers, who want themselves to be in the public limelight. Often these people do not have very good staying power - here today, gone tomorrow - and they may cause harm by leading citizen groups into being a passing fad, which would be very unfortunate indeed.

The fourth danger is that of overdramatization. Many of us feel that some drama, in some instances considerable drama, is necessary to catch public attention, to highlight problems; but there is no question at all that dramatization can be overdone, to the point where it oversteps even the widest boundaries of truth and again creates this problem of credibility. I make no apologies, then, for some dramatization; it is a valid technique in the public sphere, but I recognize the dangers of overdoing it.

And, finally, a danger is that often the members of citizen groups are rather naive, inexperienced people, and when they are dealing with the media, they may let things get out of hand and they may create the wrong impression. The most striking example of this kind of thing, that I know of, is when several project leaders in Pollution Probe decided to take on Ontario Hydro over the question of the nuclear plants, particularly the one at Pickering. The point of the press conference that Pollution Probe held at Queen's Park was completely lost due to the inexperience of the people who were handling it. The point they wanted to make is that the public, because of habits of secrecy of Hydro and Atomic Energy of Canada, Limited, did not have available all the data required to make up its collective mind on whether nuclear plants will pose problems in the future. What came through, because of the inexperience of these people, was that Probe was utterly and

irrevocably opposed, a priori, to the opening of the Pickering plant. That is not so, but it was Probe's fault that things got out of hand. This is a very real and present danger with citizen anti-pollution groups.

Now, what about the future? I personally feel that the solution to our environmental problems by the exercise of public pressure cannot be a permanent state of affairs. The technique involved in this creation of public pressure is the technique of confrontation. Obviously, a citizen group shows concern about something, feels that action is not being taken or not being taken urgently and promptly enough, creates a confrontation, catches public awareness and overwhelms the system to bring about some sort of solution - temporary though it may be. However, I do not believe that any society can order its affairs either in the field of environmental concern or in any other problem area, on a continuing long-term basis of confrontation. That just will not do. The fabric of our society cannot sustain that kind of repeated shock. Also, I do not believe that any group is capable of generating 50,000 signatures across Canada every time there is some problem that does not seem to be solved. Something has got to give, somehow. In the recent past, and at this moment in time, confrontation is still a valid and useful device, but I repeat that I do not think any society can so manage its affairs that confrontation becomes the major vehicle for decision-making and for establishing policy. Therefore, in the future, citizen groups must work more closely with government and with industry to develop, find, and apply effective solutions to environmental problems. I can also rephrase that by saying government and industry must work more closely with citizen groups. It should be a two-way street that leads to mutual cooperation and tolerance. I return to the point I made earlier, however, that with the best will in the world, this society - our Canadian public, our Canadian system - does not know, any more than any other system around the world does, how to develop long-term solutions for environmental quality management. We are just now beginning to develop partial, rather fragmentary solutions - solutions to highly specific problems that do not really solve some of the basic background problems. We must all work together effectively if long-term management plans are really to be developed and applied wisely.

Secondly, in the future, citizen groups must emphasize their educational programs even more emphatically than they have in the past, and recognize that this educational process is the single, most important, continuing thing they can do. This education, as I

mentioned earlier, may be self-education, or it may be group education in the community. But, I think, increasingly, it must move from the sensation of a stinking Don River or mercury in some lake, to try to bring about, in the public as a whole, a better awareness of root causes of some of our environmental problems - root causes such as: our continuing, simple belief that growth *per se* is a necessary, desirable, vital thing; uncontrolled population expansion; uncontrolled technological expansion; and our lack of respect and understanding for our environment.

I was struck by a comment that a gentleman made when I was on a radio show not so long ago. He was totally opposed to any suggestion that Canada today has a population problem. He utterly rejected this notion, so I asked him how many people he thought Canada should have. Well, he said, at least twice as many. What that man did not realize, and what he should be brought to realize, is that in 37 years we *will* have twice as many people in Canada as we have today and, according to the projections that are made, with the best techniques we have for levelling off population growth - techniques that would be acceptable to the majority of our society - the lead time for level-off is about 50 years. This kind of information should be checked, and then it should become part of public awareness of the background to environmental problems.

A third future role for citizen groups is continual surveillance of the progress being made in environmental quality control, and especially of the ways in which some of our new elements of legislation are being applied. We all know that we now have the new Canada Water Act, the new Fisheries Act. There is an Air Quality Act being drafted in Ottawa, and there will undoubtedly be continuing legislation at the Provincial level. This is fine, but we all know that we have had laws in the past which, if we had used them decades ago, would have prevented some of the environmental degradation that has occurred. The public in our system has to be a watchdog, it has to exercise surveillance of the progress being made by the government, and I see this as a continuing contribution that the citizen groups can make.

Finally, inevitably the citizen groups are going to become involved more heavily in legal action. There will be an increased reliance on legal action to bring about more effective pollution control. There are now citizen groups being established across Canada specifically for the purpose of entering into litigation

with government agencies and with specific industries to prevent instances of pollution, instances of environmental degradation. It seems to me that the major faults at present are that the citizen groups too often are entirely negative. Most citizen groups speak in terms of "don't" - don't do this, stop that, don't do the other thing, ban this, ban that, limit the content of this, limit the content of that. This is natural but it is unfortunate and I think citizen groups should be more concerned with trying to make positive suggestions in addition to the endless stream of negative suggestions. On the other hand, I think the targets of their pressure - industry and government - too often are totally defensive. This is a very natural human reaction but it is not a very productive one. Government agencies particularly tend to cower into the background when confronted by an angry, militant citizen group and this simply creates further polarization. It would be far better if government agencies and industry could bring themselves to talk constructively with citizen groups, and vice versa. Moreover, there is too much blame being cast about. Government is blaming certain components of our society, industry is blaming others, and society as a whole is finding targets for blame with regard to pollution. This is a wasteful exercise of energy. It is not really a question of blame at all: we are all to blame in this question of environmental quality. I was interested by the question from the gentleman from the Department of Fisheries and Forestry when he asked "who's going to pay for pollution control?" I do happen to agree with his Minister. I do not think industry is going to pay, I do not think government is going to pay, I think we are all going to pay. There's only one pocket, one ultimate pocket, in our society, and that is yours and mine. And the question of blame then - who did what in the past, who's being a bad boy now - just doesn't matter anymore. What I do think deserves blame, however, is inertia; that is, resistance to the idea that there is a problem or that it is capable of solution. I think untruthfulness, deliberate untruthfulness, to defend pollution or defend a certain situation, is worthy of considerable blame, and I think unwillingness to act is also cause for blame. Consider the DDT problem of two years ago in this context of blame. We used DDT extensively for 25 years. Nobody was to blame for that, because collectively we demanded high quality appearing fruit and vegetables. The farmers demanded cheap, effective, relatively safe material. We all went along with that. But the person, or the group of people, that I blame are those who, as scientific information about the harmful effects of DDT to wildlife, and the real possibility that it is a carcinogen became a flood, shut their minds and shut their eyes to

this information, dug themselves a defensive hole and tried to retain the use of DDT. That, I think, is genuine cause for blame.

I want to close with a word about emotionalism. This is a very frequent criticism of academics who are going out into the real world and showing concern over environmental quality, and especially of citizen groups. You hear that they are too emotional or they are only an emotional crowd, they are emotional nuts. What's wrong with being emotional about the issues of environmental quality, pollution, and environmental degradation? How can one avoid it if one really has genuine concern over these issues, and one sees signs of environmental destruction on every side and knows that, ultimately, this could be a matter of survival? What's wrong with being emotional about these things? There is room in all of the plans that we set in motion for environmental quality control for the feelings of people, for personal feelings, for the application of ethical standards as well as scientific standards and economic standards, and I think there is an abundance of room for human wants and human needs. I suggest, ladies and gentlemen, that one cannot measure all aspects of environmental quality with a slide rule. A quiet sense of outrage may help as well. Thank you.

SESSION CHAIRMAN,
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K.J. Platt

"PROCESSING OF POULTRY WASTES"

BY

KENNETH J. PLATT,
VICE PRESIDENT - CAPITAL IMPROVEMENTS

CAMPBELL SOUP COMPANY LTD.,
TORONTO, ONTARIO.

Campbell Soup Company Ltd. markets 23 varieties of canned soups or related products in various size packages that contain chicken or turkey meat. In addition, we market 13 varieties of frozen dinners, pies and related items containing poultry meat. This involves the procurement of substantial quantities of poultry and has resulted in the establishment of a poultry growing operation in South Western Ontario.

Live poultry from the growing buildings or from outside purchases is delivered to a killing and eviscerating plant which is physically divorced from the growing operations. This was originally located on the same site as the manufacturing plant which produces chicken and turkey dinners. For a variety of reasons, we recently decided to separate these operations and build a new poultry killing and eviscerating plant at some remote location. In selecting a site for the new poultry killing plant, besides the usual engineering and economic considerations, two major points had to be kept in mind. First, the plant had to be located reasonably close to our growing buildings so that the young broilers could successfully survive the trip to the killing plant in exposed cages on conventional

poultry transport trucks during severe winter weather. Secondly, the site had to be acceptable for the disposal of waste from the operation.

The plant was designed to process 30,000 head of poultry on an 8-hour shift, and in addition to the killing and eviscerating operations, we planned for a future expansion to include poultry cooking. The actual waste load, including the future expansion plans, was equivalent to a city having a population of approximately 15,000 people. It is our feeling that food processing plants, and especially a plant of this nature, should be located in a rural community and it was extremely unlikely that rural communities would have waste treatment facilities available having sufficient capacity to treat this amount of waste. Of the several municipalities that were investigated that had a population of less than 10,000 people, none had adequate water or waste treatment facilities or could provide them. Of the larger communities, only one city that was investigated had acceptable waste treatment facilities, but this location was abandoned for other considerations. While we do not like to be in the water supply or waste treatment business, we decided to provide our own water supply and build our own waste treatment plant.

The prime requisite in site selection resolved itself to waste treatment, and to assist in this search we retained the services of a consultant who was a former chief executive officer of the Ontario Water Resources Commission and we maintained close contact with the Commission. After considerable search we selected a site, took up options on land, but as a result of subsequent discussions with the Ontario Water Resources Commission the site was abandoned because of the recreational aspects of the receiving stream and the excessive costs of the waste treatment facility that would have been required. We ultimately decided to locate the plant in Blanshard Township about one mile downstream of the Town of St. Marys, with the effluent discharging into the Thames River.

The Thames River drains a huge watershed, with numerous communities, farmlands and industrial enterprises located along its shores, all of which treat their waste to varying degrees. The Ontario Water Resources Commission has strict effluent standards to which our plant had to be built, and it appeared prudent to determine the quality of the water in the Thames River upstream and downstream from our proposed plant location. We arranged with the Academy of Natural Sciences of Philadelphia to plan and coordinate an ecological survey following consultation

with the Ontario Water Resources Commission and the results were made available to the Commission. The objective of the study was to determine the variations in the biota and water quality and to evaluate the effect of the plant operation, if any, on the environment. Four sampling stations were selected----one upstream of the Town of St. Marys, two downstream of the Town of St. Marys and upstream of the plant location, and one downstream of the plant location. Besides monitoring the aquatic vegetation, samples were collected and analyzed for BOD, COD, suspended solids, total solids, as well as for complete chemical analyses.

Since the plant was put into service, monthly samples are taken at the identical stream locations and analyzed to determine the effect of the plant on the river. This work is routinely done by the University of Western Ontario and Prosearch Limited. In addition, regular analyses are made to determine the efficiency of the operation of the plant itself. The closely co-ordinated teamwork of our engineers and consultants ensures that the quality of our effluent is acceptable and to date it is superior to the quality of the raw water in the Thames River at the upstream sampling stations.

Our poultry products all bear the Government approved legend and our operations must, therefore, be continually monitored by the Department of Agriculture, Health of Animals Branch. We have a staff of six Government inspectors per shift assigned to the plant. After killing and defeathering, the viscera is exposed on each individual bird for examination by the Government inspector. Any diseased birds are rejected and must be consigned to a condemned waste area. Waste from approved birds must be kept separate and, so, we have two entirely separate waste rooms. Feathers which are removed before the individual birds are inspected are considered to be condemned waste and must be consigned to the condemned waste area. Blood which is also released before Government inspection must similarly be considered condemned waste. The condemned waste also includes screenings from the floor drains, fat and grease from waste separators, etc. The inspected waste consists of offal from the approved birds, sterilized blood, etc. The feathers are dropped from the defeathering machine to flumes in the floor where they are conveyed to rotary screens in the condemned waste room. The feathers are dewatered, elevated to specially designed hoppers and trucked from the property for use in the manufacture of feathermeal. The blood from the killing operation and the lungs which are removed by vacuum equipment

at the eviscerating line are conveyed by a vacuum system to storage tanks in the condemned waste area, pressure sterilized, with the sterilized blood being discharged into the inspected waste area from which it is removed for sale.

Offal, including heads, from the eviscerating operation, after government inspection, is dropped into a stainless steel flume and conveyed to the inspected waste area where it is separated by rotating screens, collected in storage tanks and sold. The feet from the inspected birds are collected in containers, transferred to the inspected waste room and sold. Livers are frequently reclaimed and frozen for sale.

All of the wastewater from floor drains, wash-up operations, from the offal and feather screens, etc., is conveyed to our main in-plant screening and fat separating equipment. This wastewater flows at a controlled rate from a weir box into two rotary screens equipped with 3/32" openings which screen out the large particles of solid matter before the liquid enters our fat separator. The fat separator is about 40' long and provides approximately one hour settling time. The fat that rises to the top is continually skimmed off by travelling skimming bars that move forward on an intermittent basis. The solids that are heavier than water sink to the bottom of the separator tank where they are picked up by slow-moving traveling bars and conveyed to a spiral screw for removal from the bottom of the separation chamber. The fat and solids that are removed in the in-plant screening and settling operations are sold to an outside rendering plant. The overflow from the system is measured by a recording meter and delivered by pipe line to the main waste treatment plant.

From the above brief description you will note that we have taken elaborate precautions to minimize the organic loading on the waste treatment plant by the separate collection and disposal of blood, viscera, fat and rough screenable solids. We have also taken precaution in the design to reduce the hydraulic load as much as possible. Uncontaminated water from roof drains and surplus refrigeration condenser water is diverted directly to the storm sewer and drainage ditches. We have substantial quantities of refrigeration condenser water from the icemakers and refrigeration machinery rooms. This water is reclaimed and part of it is used to flush the offal away from the eviscerating operation to the offal recovery system. It is also used to flume feathers to the waste room where it is again collected and pumped back to the

defeathering machines. Reclaimed water is also used for continuous spray washing of all of the dewatering screens.

Sanitary waste from the washrooms throughout the plant is collected in a separate pipe system and conveyed to a septic tank. The liquid outflow is chlorinated and discharges by gravity for further treatment in our main waste treatment facility.

In our search for an acceptable site, we acquired approximately 175 acres of land and located the processing plant and the waste treatment facility remote from all existing roads and houses to minimize any potential odour complaints and to provide adequate land for tertiary treatment of waste in the event this might become necessary at some future time. Simultaneously, we obtained options on adjoining land in the event that its acquisition might be desirable.

In selecting the plant site we sought out a location that would permit a complete gravity flow of our liquid waste from the processing plant to the waste treatment plant and ultimately to the river. This was desirable not only to minimize shutdown due to pump failures and reduced operating costs but to minimize problems during periods of power interruption, etc.

We engaged Proctor & Redfern to design the waste treatment plant for us and Mr.C. S. Dutton, associate partner and head of their waste treatment division, is here today to assist me in answering any technical questions that you might raise. We determined that the waste going to the treatment plant would initially amount to about 500,000 Imperial gallons per day, with about 1,900 pounds BOD content, and ultimately the plant should be capable of treating 733,000 Imperial gallons per day having a BOD content of about 2,565 pounds.

The consulting engineers' assignment was to design the waste treatment facility to handle this volume of waste and to produce an effluent for discharge to the Thames River that met with the Ontario Water Resources Commission's effluent standards.

Poultry plant wastes respond readily to biological treatment and the poultry waste processing operation has become fairly standardized. As a result, it was not necessary to carry out pilot plant testing, and we concluded that only the activated sludge process,

or one of its various modifications, was capable of approaching the BOD reduction required. After due consideration, our consultant decided to treat the waste by the extended aeration or total oxidation activated sludge process. Waste activated sludge is a by-product of any activated sludge process, and the extended aeration method was selected in order to minimize the problem of treatment and disposal of the waste sludge.

Most waste treatment plants are constructed for the treatment of municipal sewage and are designed along a preconceived pattern in a totally enclosed building using expensive concrete tank construction. Most consulting firms have a background of municipal sewage plant design, and the construction methods and standards are not necessarily applicable to an industrial waste treatment facility. We asked the engineers to design a low-cost and efficient plant for us, keeping the use of mechanical equipment to the absolute minimum. The design as finally developed consists of a lined earthen basin---the central zone of which is the mixing and aerating zone with a settling zone on each of the two longitudinal sides. After excavation, the sides were lined with dry pack concrete and the bottom of the basin was paved with a conventional 4" concrete base. The maximum liquid depth within the aeration basin is about 16 feet and about 3 feet freeboard is provided. The aeration zone was sized on the basis of 15 pounds of BOD per day per 1,000 cubic feet of aeration zone volume. The aeration zone is equipped with mechanical surface aerators with draught tubes. There are four such aerators. These are supported on structural steel platforms with access walkways to each aerator. The waste from the processing plant is distributed into four equal portions by four influent pipe lines which direct the flow to each of the four aerators.

The settling zones are separated from the aerating zones by means of baffles which consist of transite sheets bolted to an aluminum frame which is anchored to the bottom and sides of the basin. On the aeration side of the frame the transite sheets are full height with intermittent 6" slots approximately 3 feet below the high liquid level point. On the settling chamber side, and separated by about 18", similar sections of transite sheets are bolted to a depth of about 10 feet only. The settling zones are sized to comply with good sedimentation tank practices. At ultimate flow the rise rate in the settling zone is less than 250 gallons per square foot per day and the weir overflow rate is in the order of 1,500 gallons per foot of weir length per day. Inlet ports and baffles are

provided to minimize turbulence and to ensure that the incoming liquid is directed downwards to the bottom of the settling zone.

The settling zones are equipped with adjustable effluent weirs which permit the depth of penetration of the aeration turbines to be varied, giving a control over the degree of aeration within the aeration zone. This is most desirable because it is necessary at times of low waste flow (such as the weekends) to minimize aeration in order to avoid the destruction of mixed liquor solids.

The sludge is returned from each of the two settling zones to the aeration zone by means of air lift pumps. There are 14 such air lift pumps to each settling zone leaving a spacing between the air lifts of about 6 feet, a distance which has been proved in practice to be adequate to ensure that there is no undue sludge accumulation. The air supply to the air lifts is adequate to give a maximum sludge return pumping equal to 200% of the throughput. The air lifts terminate just above liquid level in the aeration zone and the air supplied to each air lift is equipped with its own control valve, thus making it possible to observe and to regulate the discharge of return sludge from each air lift. A dual set of air compressors is available for standby emergency use.

The arrangement of the influent flow to the aeration zone, together with the pattern for returning the settled sludge and the method of collecting the effluent from the settling zones, does ensure that the flow pattern through the aeration zone is basically that of a completely mixed activated sludge system.

A biologically smooth operation can be approached best with complete mixing in which the wastes and the returned activated sludge are added uniformly throughout the entire aeration tank. Under such conditions, the dilution of the waste throughout the entire aeration tank reduces the food to micro-organism ratio and permits the microbil population to remain as close to equilibrium as possible.

In an activated sludge process having no primary settling or scum removal prior to aeration, a surface scum will eventually accumulate in the secondary clarifiers. To overcome this potential problem, we installed a number of the de-scumming devices at the surface of each of the two settling zones. Each descumming device consists of a trough positioned at the liquid surface with the outlet from the trough being

connected to an air lift pump so that when air is applied scum is pulled into the trough to be discharged back to the aeration zone.

In an extended aeration activated sludge system, to ensure maximum treatment efficiency, it is necessary to bleed a certain amount of sludge solids out of the system from time to time. A separate sludge storage basin of earth construction is provided to receive such waste sludge. The sludge is wasted to the sludge storage basin by a gravity line from the bottom of the two settling zones. The sludge storage basin was sized to give a capacity of about 100 days volume of surplus sludge on the assumption that the excess sludge is in the order of 1.25 cubic feet per 10 pounds of applied BOD to the aeration tank per day. The waste sludge basin is unlined, has side slopes of three horizontal to one vertical, and when full has a liquid depth of 12 feet.

Sludge from an extended aeration system is essentially stabilized and can be readily disposed of without nuisance. Approximately 10 acres of land adjacent to the sludge storage basin was prepared for spray irrigation. The selected land had a contour that generally met our requirements, but it was regraded to form a continuous uniform slope with all rocks and debris removed. After plowing and discing, it was treated with limestone, fertilized and seeded with a mixture of Reed Canary, Meadow Fescue and Perennial Rye Grass. During the spring, summer and fall months the sludge is sprayed onto this prepared area. During the wintertime, the sludge is accumulated in the sludge storage basin and spray irrigated during the spring and summer. The rate of application is such that there is no surface run-off and there is considerable adjacent land available for an extension to the spray irrigation system in the event it should be needed in the future.

The effluent from the overflow weirs on the two settling chambers combine at a manhole and chlorine contact chamber where it can be chlorinated before discharge. The plant is located approximately 23 miles upstream from the Fanshaw Dam where the artificial lake is used for recreational purposes during the summer months. The effluent is chlorinated during the recreation period, but in the wintertime it discharges without chlorination. The effluent from the chlorination chamber is taken by a 12" outfall sewer approximately 3,000 feet in length to a submerged diffused outfall located in the center of the Thames River.

For safety purposes, the waste treatment plant is completely enclosed by conventional industrial fencing, and safety rails have been installed around the entire perimeter of the aeration and settling chambers. In spite of the industrial fencing and snow fencing, there is a considerable build-up of snow in the area and plantings of coniferous trees have been made to provide effective snow and wind breaks.

Meeting the Ontario Water Resources Commission's standards at an acceptable price has called for a good deal of ingenuity, and our consultants have responded and responded well. They have developed an effective process at less than half the capital cost of a conventional activated sludge plant. The operating and maintenance costs are quite reasonable. About 20% of the total plant investment represents waste treatment facilities. We believe that we looked ahead, planned well and carefully studied the characteristics of the receiving stream, and do not anticipate any unpleasant surprises in the future.

P.M. Wong

"PRIMARY TREATMENT OF NEWSPRINT MILL EFFLUENT INCLUDING SOLID WASTES INCINERATION"

BY

PO MAN WONG,
WATER QUALITY SUPERINTENDENT

THE GREAT LAKES PAPER COMPANY, LTD.,
THUNDER BAY, ONTARIO.

INTRODUCTION

The Great Lakes Paper Company, located by the Kaministikwia River in the City of Thunder Bay, Ontario is the largest single pulp and paper mill in eastern Canada. The mill manufactures newsprint paper, groundwood and bleach kraft pulp as well as unbleach sulphite pulp. In 1970, saleable production was over half a million tons.

The Company started its effluent control work in the early 1960's. In 1965, a 10-year program for positive effluent control was initiated.

This program was carefully weighed on the basis of three determinants, namely:

(a) Water is our life blood line
(b) The ambition to be good corporate citizens
(c) The ability to pay - No private industry has unlimited funds for effluent control if the company is to hold its ground in the highly competitive world market.

In 1967, following the start-up of the new kraft mill, the first phase of our primary treatment system which deals mainly with kraft mill wastes was completed.

Details of this phase were outlined and discussed in the first and the 4th Paper Industry Air & Stream Improvement Conferences respectively (See Note (A) and (B)). It took us two years to analyze the results from the first phase of the program and to pave the way for the next (e.g. outstanding performance in clarification but difficulty with grit in Centribed system and in Centrifuge operation).

The final stage of the primary treatment system came on stream early this month. This unit which we call Newsprint Effluent Treatment Plant provides facilities for bringing the balance of all mill liquid wastes together for primary treatment. In addition, the project also includes solid waste incineration.

OBJECTIVES

The objectives of the Newsprint section are as follows:

(1) To bring all scattered raw sewers together for treatment.
(2) To remove suspended solids from liquid wastes
(3) To correlate the mill process with effluent control
(4) To collect data for future treatment
(5) To control pH if necessary
(6) To maintain a continuous record of mill effluents
(7) To dispose fibrous solid waste such as clarifier sludge, bark and mill debris.

GENERAL

The Newsprint Primary Treatment system consists basically of an interceptor, a pumping station, a pumping main, a distribution chamber, two clarifiers, two coilfilters and a fluidized bed incinerator (as shown in fig. 1).

INTERCEPTOR

The newsprint section had a growth pattern extending over a number of years and is now an amalgamation of the various components into a completely integrated operation.

NOTE: (A) "PRIMARY TREATMENT OF EFFLUENT AT G.L.P." by Van Luven., Van Luven Consultants Ltd., at the 1st Paper Industry Air & Stream Improvement Conference, 1965.

(B) "PRIMARY TREATMENT OF KRAFT EFFLUENT AT G.L.P." by P. Wong, G.L.P., at the 4th Paper Industry Air & Stream Improvement Conference, 1968.

The company originally started out with a single mechanical pulp mill in the early 1920's. Through years of growth and expansion, the company has added 4 paper machines, a sulphite mill, a steam plant, a new grinder room and a water treatment plant in and adjacent to the original building. Due to the differences in orientation, each additional mill has a separate sewer system discharging at various points to the river. An interceptor consisting of two collecting sewers was installed to divert all these scattered old sewers into one stream (see fig. 2). These two sewers are designated as line A and B. Line "A" which collects wastes from the Sulphite Mill, the old Grinder Room, the Paper Mill and the New Woodroom, is a tile-lined reinforced concrete sewer about 200 ft. long with a 5'-6" square cross-section. Design capacity is 167 cubic feet of effluent per second.

Line "B" is an A.W.W.A. C-301 reinforced concrete pipe, 30 inches in diameter and almost 1,000 ft. long with bell and spigot joints. Its main function is to collect wastes from Woodrooms and the Water Treatment Plant.

Line "B" is not designed for corrosive service and, therefore, was located high above line "A" to avoid backup of corrosive wastes from the latter into the former when two lines meet in the manhole ahead of the pumping station.

PUMPING STATION AND SCREENS

Limited by the geographical features of our mill site, the company had to install the two clarifiers at an elevated location.

A pumping station was built to transfer the combined waste from the interceptor to the clarifiers. At the pumping station, the combined waste stream is divided into two 8 ft. wide channels where it passes through bar screens with 1½ inches spacing and then through travelling screens with ½ inch mesh opening. The travelling screens are 7 ft. wide by 31 ft. centre (sprocket shaft to sprocket shaft). Particles which collect in the baskets of the travelling screens are carried up to a discharge trough from which they are washed into a shredder. The shredded solids are returned by gravity to the waste stream on the upstream side of the screens. Any oversize particles are returned to the shredder by the same process. The purpose of screening is to protect downstream equipment. The screen assemblies and shredder are all controlled automatically by the level differential between the upstream and downstream sides of the screens.

The screened waste flows to a common sump from which effluent is pumped through a 1,500 ft. pumping main to

a distribution chamber at an elevated location by means of three vertical centrifugal pumps. Each pump has a capacity of 20,000 USGM at 100 ft. T.D.H. One of these pumps is driven by a variable speed drive unit coupled with a reducer gear. This pump facilitates a variable pumping ability ranging from zero flow to full pump capacity. The operation of these pumps is controlled pneumatically by the level of the sump. Their sequential action is illustrated in fig. 3.

At the distribution chamber, the waste is diverted equally into the two clarifiers.

CLARIFICATION

Each clarifier is 160 ft. in diameter by 12 ft. S.W.D. Their design surface loading rate is 1,200 gal./sq. ft./day with a suspended solid removal efficiency of 80-90%. These design parameters are based on the success of our Kraft N.F. Clarifier which has performed well with an identical high rise rate. No doubt, these numbers are outstanding as compared to the settleability of domestic sludge.

In the clarifiers, settleable suspended solids are scraped to the central sumps where they are allowed to thicken to a slurry of 2 to 6% consistency. The scraper arm mechanism is capable of handling 700,000 ft.-lb. torque at peripheral speeds up to 15 ft./min. Each clarifier is equipped with a surface skimming arm and a scum collecting box (see fig. 4). Settled sludge and the collected scum are pumped to two coil-filters or a centrifuge (Kraft) for dewatering. Clarified effluent flows to a channel where it mixes with treated kraft effluent before discharging into an under-water diffuser in the river.

The reason that our company has installed two-160' clarifiers rather than 1-230' clarifier (even though the additional cost to the company has been in excess of 6% of the cost of the system) is to protect the environment in case of mechanical failure of a clarifier.

DEWATERING BY COILFILTERS

As a result of high maintenance cost in the dewatering system of the kraft section, coilfilters were chosen to take the place of centrifuge. The coilfilters are rotary vacuum filters with coilsprings as filter media. The springs are placed in corduory fashion around the drum to allow maximum surface area and positive cake discharge. Each filter is 11½ ft. long and 10 ft. in diameter with a design rate of 13.2 lb./hr./sq.ft. at the design input consistency of 2-3% and a discharge consistency of 20-25% solids. The filtrate is fed back to the clarifier while the filter cake is conveyed to the fluidized bed for incineration.

INCINERATION

In our case, solid disposal by landfill is too expensive and impractical. Attempts were made to incinerate fibrous solid waste in a conventional bark burner. However, grit embedded in the clarifier sludge and bark have not only been proved harmful to various dewatering systems in the kraft treatment plant, but also detrimental to the operation of a bark burner. The high ash content and low heat value of the solids has resulted in tremendous amounts of residue from incomplete combustion of organic material which must be disposed of as landfill. This debris problem will continue to exist as long as the present means of mechanical logging prevails. To answer the solid waste disposal problem, a fluidized bed incinerator is being installed. Although fluidized bed incinerator has been used in other applications for pollution control, it is new for this service.

The advantages of this incinerator are as follows:

(1) To dispose all fibrous solid wastes by complete combustion

(2) To eliminate landfill of noncombustibles as grit and sand in the sludge will be used to maintain the bed level

(3) To ensure no "Black Smoke" admitted into the atmosphere.

The incinerator uses a fluidized bed of sand at high temperature for thermal oxidation of clarifier sludge, bark and mill debris.

Bark and mill debris will be crushed before they are conveyed to a silo for controlled disposal. Clarifier sludge, however, will be fed continuously to the reactor as shown in fig. 6.

The reactivator consists of a wind box separated by an orifice plate from the fluid bed zone, and a freeboard zone in the upper section (see fig. 7). Air is pumped into the wind box and passes through the orifice plate over the entire cross-sectional area of the hot bed. All combustion takes place in the fluid bed. The dispersed air will cause the fluid bed to take on heterogeneous motion and set up a continuous violent mixing action of sand, air and combustible materials. In this stage the bed will itself resemble a body of boiling water.

The exhaust gases from the reactor will be scrubbed before emission to the atmosphere. Discharged particulate matters in the dry gases are expected to be less than 0.02 gr./SCF. Hot water generated from the scrubber will be used in the woodroom for the barking purpose. The projected mass balance for the incinerator system is shown in fig. 8.

pH CONTROL

The pH of clarified newsprint effluent is expected to be within the acceptable range, pH of mixed kraft and newsprint effluent can be controlled by adjusting the pH of the kraft mill effluent. The kraft mill primary treatment plant is equipped to do so.

DATA COLLECTION AND RECORDING

The newsprint primary treatment plant is equipped with modern instrumentation to measure and record data such as conductivity, pH, turbidity, temperature and flow from various sewers as illustrated in Table 1. The importance of good record in this system cannot be over-emphasized. Past experience with the kraft treatment plant tells us that sophisticated instrumentation will assist in reducing the sewer losses; correlation between effluent and mill process; provision of sound record to deal with unfounded statement; and the most important of all, will assist in obtaining all the essentials to design the future effluent treatment. As stated, we are locked in by the geography of our mill site such that there is not sufficient room for aerated lagoons, and consequently, any further biological treatment will be done by means of some chemical/mechanical process. As you may know from our recent news release, over the last two years a large scale secondary pilot treatment plant survey has been conducted in the mill to determine what our future treatment will be. It is quite hopeful that we can find out in the near future (with collected data) if it is more economical to build a sulphite recovery or to treat the entire effluent biologically.

INSTALLATION COST

Cost of the primary treatment system for newsprint liquid wastes was approximately 4 million dollars and of the solid waste disposal system, nearly 1 million dollars.

The entire system has been installed in cooperation with officials of the regulatory agencies of the Province of Ontario in order to meet the acceptable standards.

The writer is grateful to Mr. C. J. Carter and to his colleagues for their advice and assistance.

TABLE 1: INSTRUMENTATION AT VARIOUS SEWERS

LOCATION	CONDUCTIVITY	pH	TURBIDITY	TEMPERATURE	FLOW	MISCELLANEOUS
SULFITE MILL	x	x	x	x	x	
PUMPING MAIN	x	x	x	x	x	flow integrator
COILFILTER					x	flow integrator
CLARIFIER (EFF.)	x		x	x		scraper torque
COMBINED EFFLUENT TO RIVER	x	x	x	x	x	flow integrator

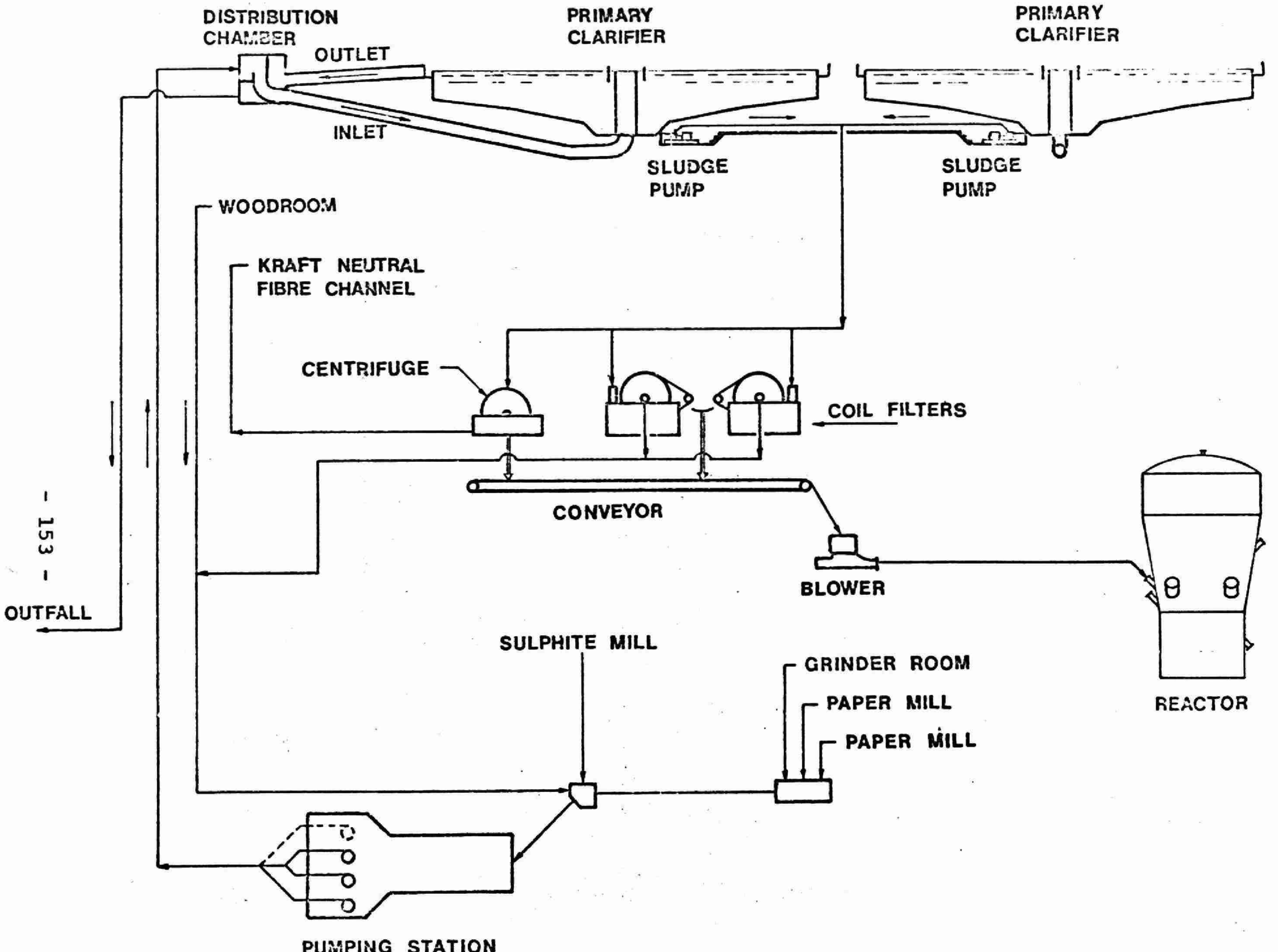


FIG. 1 NEWSPRINT PRIMARY TREATMENT SYSTEM

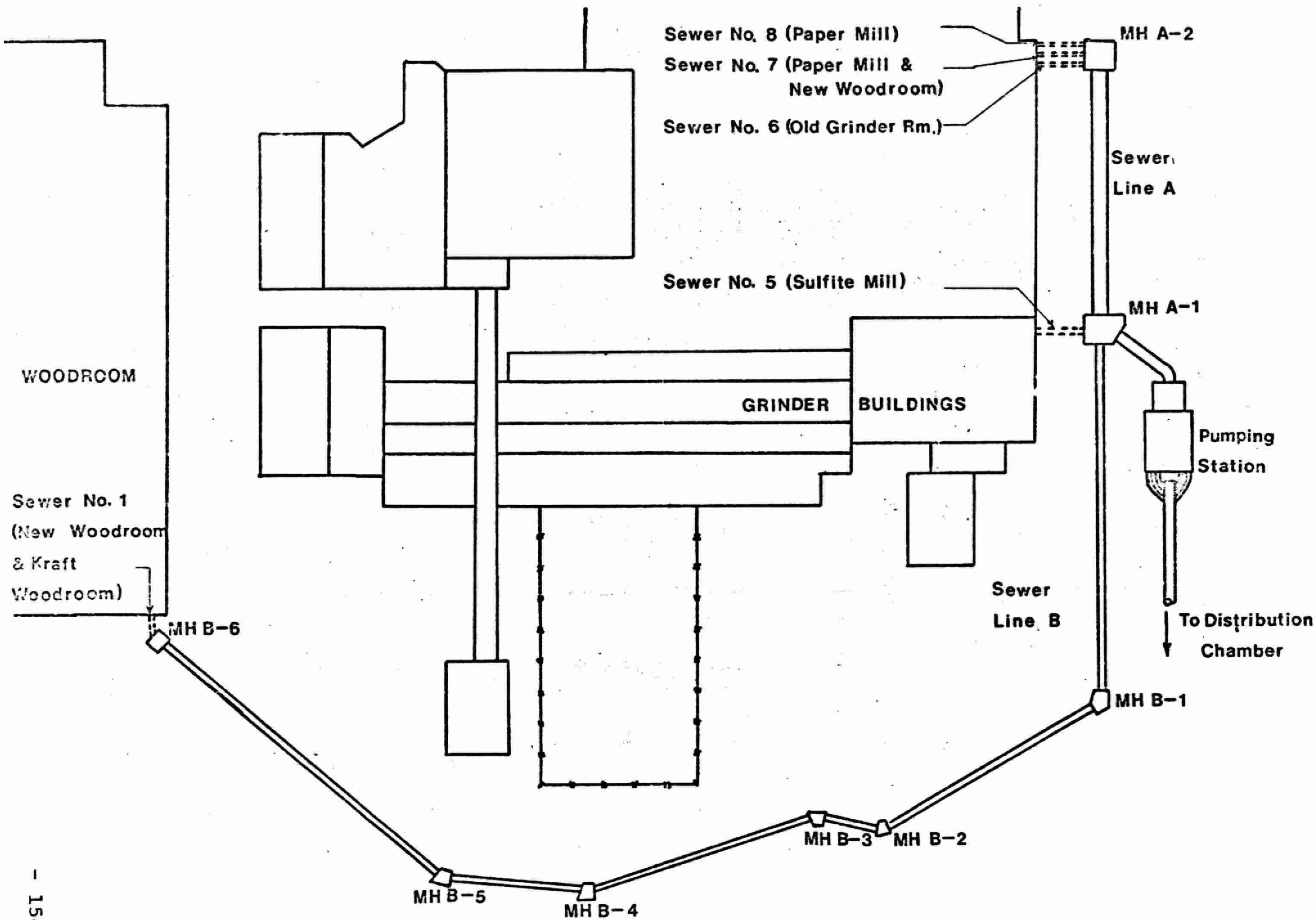
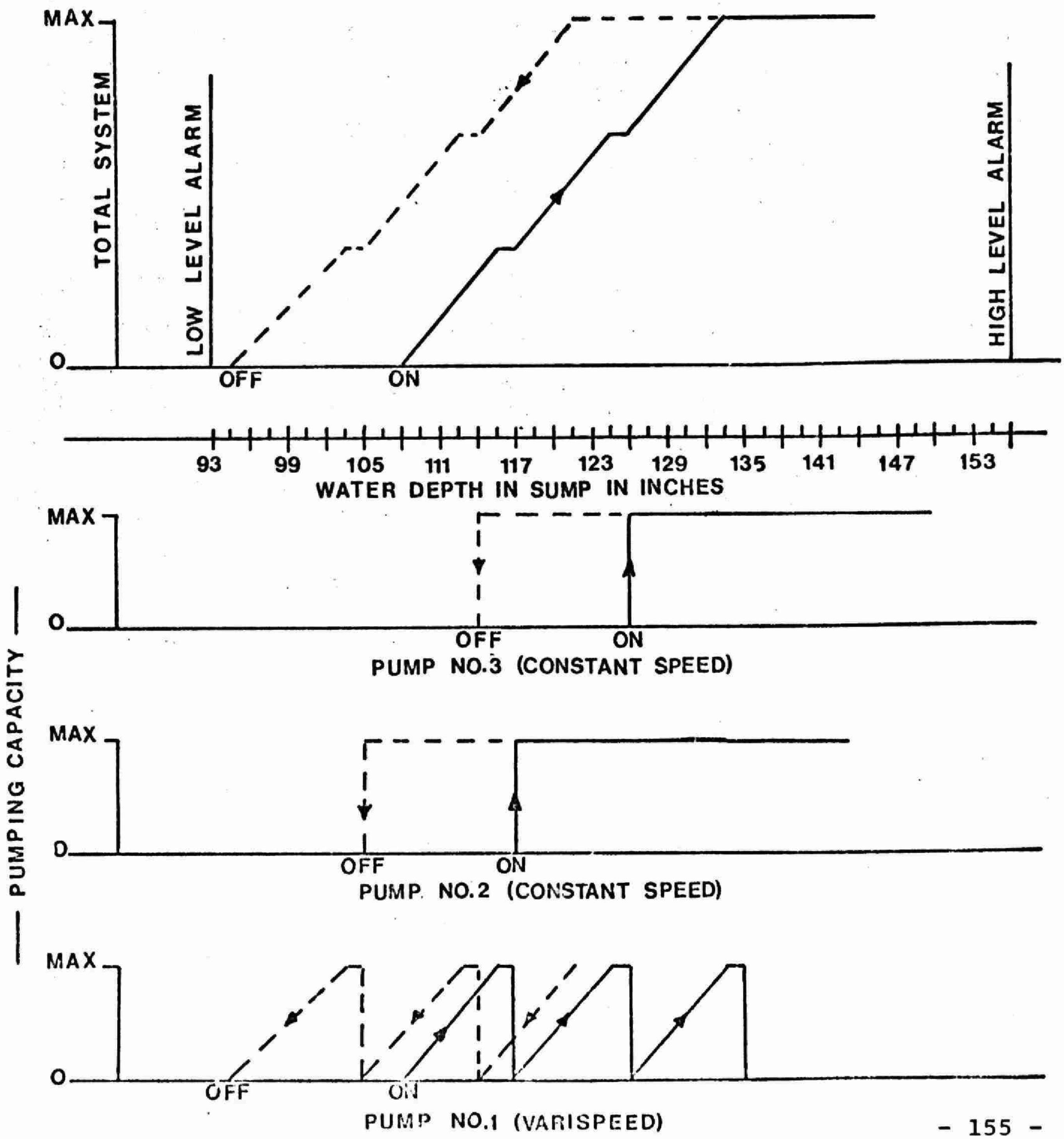


FIG. 2 INTERCEPTOR SEWER SYSTEM

FIG. 3 CONTROL CHARACTERISTICS OF LIFT PUMPS



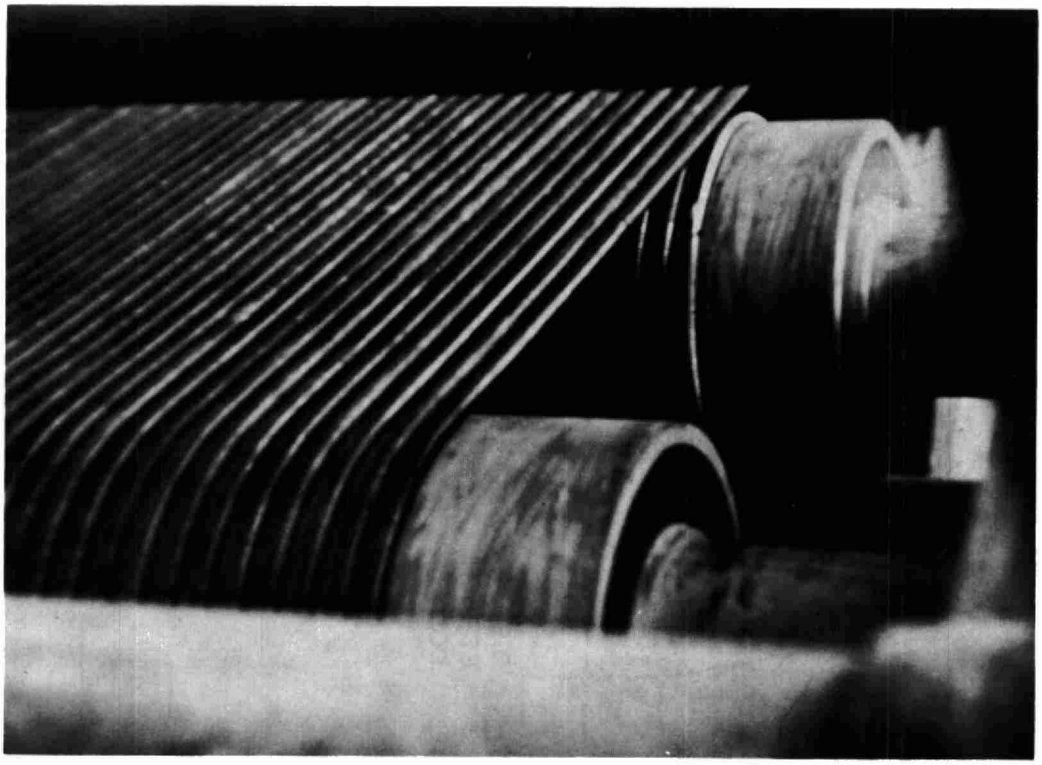


FIGURE 4 COIL FILTER

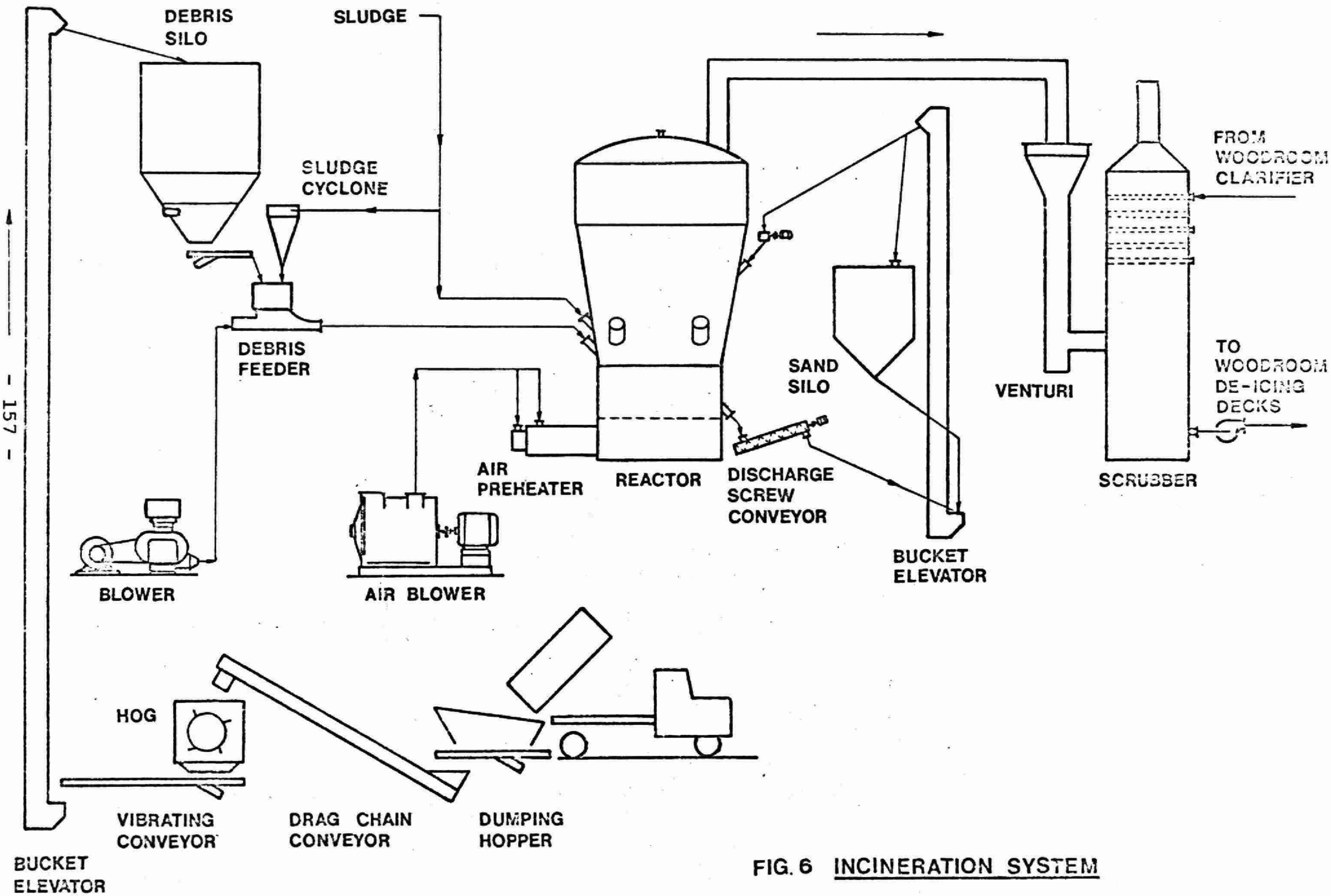
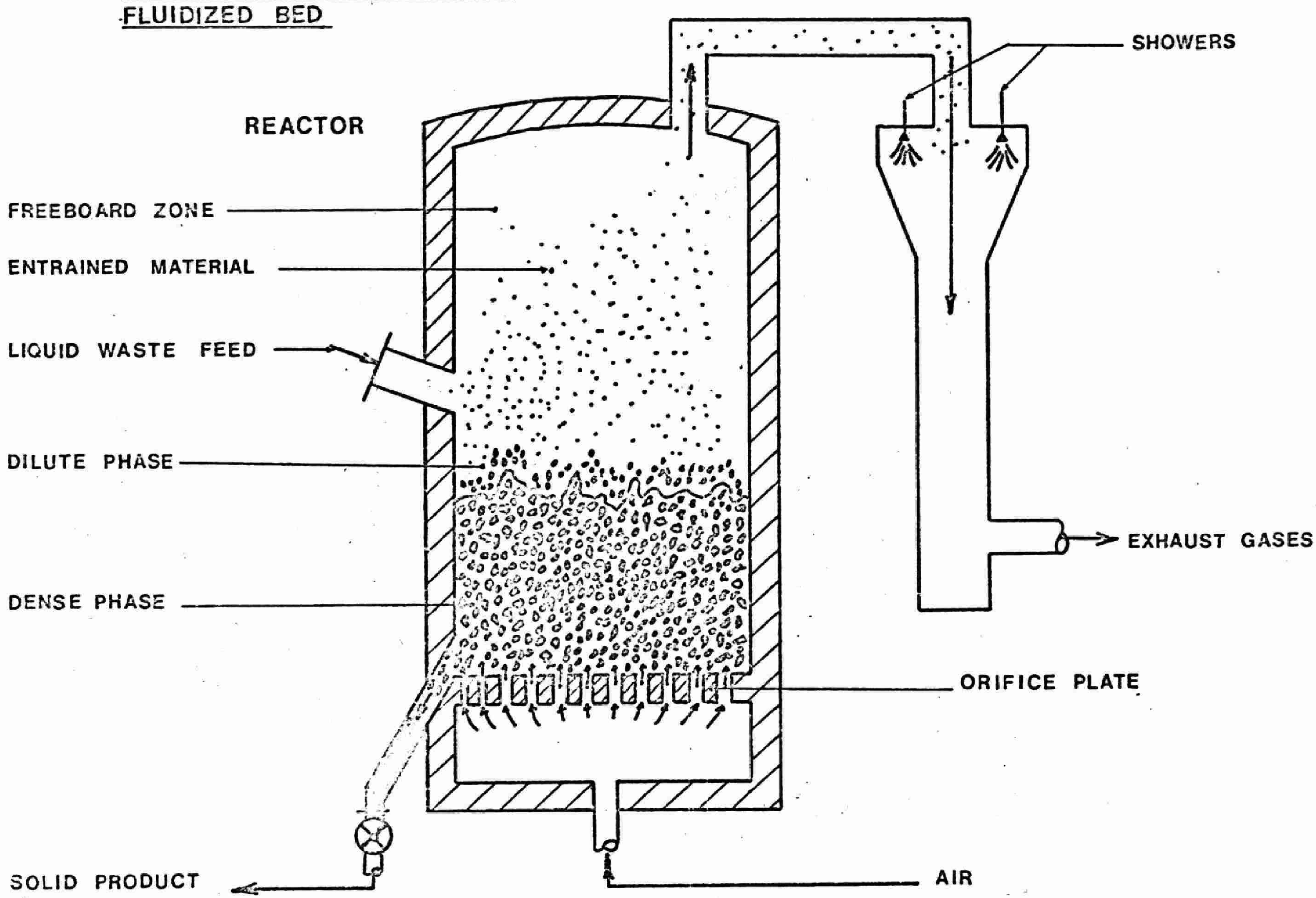


FIG. 6 INCINERATION SYSTEM

FIG. 7 SOLID WASTES DISPOSAL BY FLUIDIZED BED



FEED 1	LB/HR D.S.	LB/HR ASH	LB/HR WATER
Groundwood Sludge	3330	74	9990
Kraft Mill Sludge	420	10	1260
Groundwood Rejects	"	8	"
Kraft Mill Rejects	"	"	"
Total Feed 1	4590	100	13770
FEED 2			
Bark & Wood Debris	4160	85	7740
Surplus Bark	1670	35	3100
Total Feed 2	5830	120	10840

Gases Vented to Atmosphere

	LB/HR	VOL. %
N_2	63380	55.5
O_2	5346	4.1
CO_2	17458	9.7
SO_2	11.7	0.0045
H_2O	22500	30.7
Dust	3	-

TOTAL FEED 1 & 2
10420 220 24610
AIR FOR PNEUMATIC
CONVEYING 2800 CFM

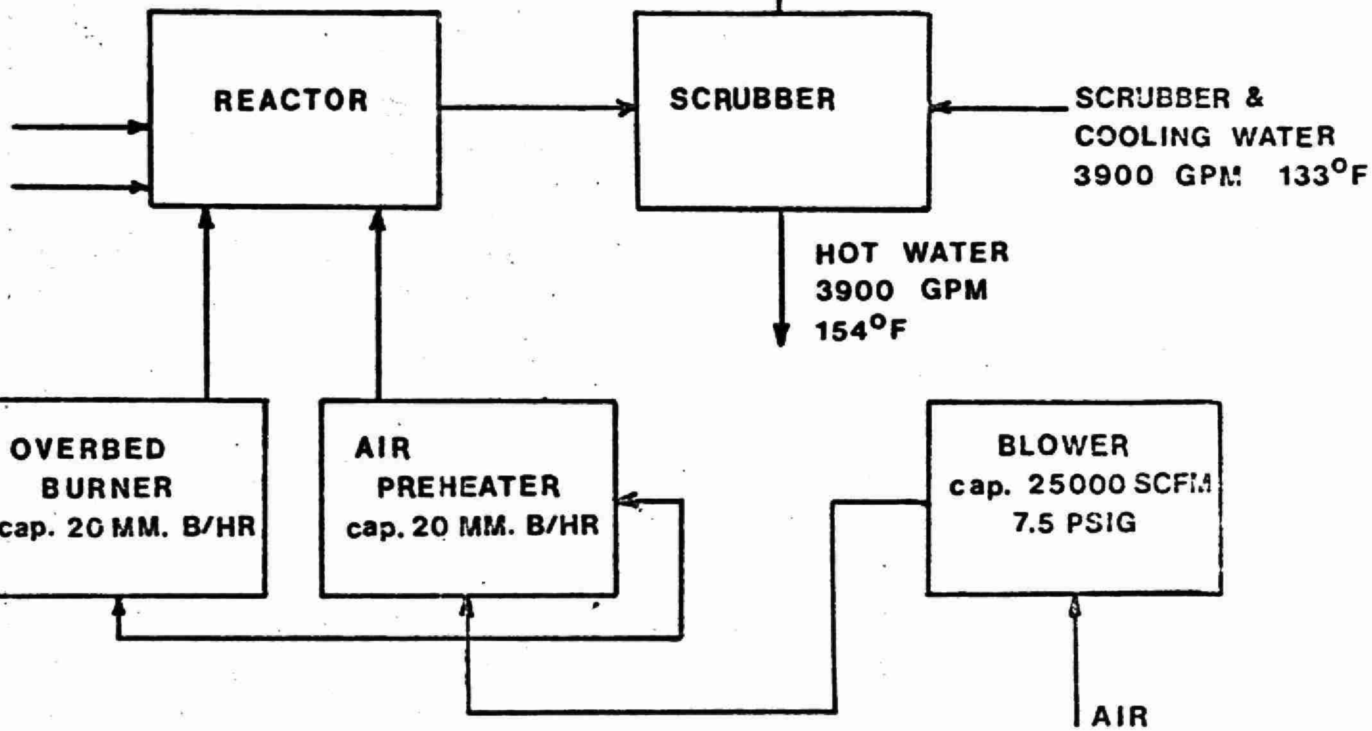


FIG. 8 INCINERATOR MASS BALANCE

B.I. Boyko

"AERATED LAGOONS IN INDUSTRIAL WASTE TREATMENT"

BY

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INTRODUCTION

The use of aerated lagoons in the Province of Ontario as a wastewater treatment process is relatively new, with virtually all aerated lagoons being constructed within the last decade. Most of these installations are located in Southern Ontario, an area of temperate climate with January mean daily minimum temperatures ranging from $2^{o}F$ to $20^{o}F$, and July mean daily maximum temperatures of $76^{o}F$ to $82^{o}F$.

The majority of the aerated lagoons have been designed as complete treatment facilities for industrial wastewaters with effluents being discharged to a watercourse; however, these effluents do not compare in quality with those normally associated with secondary treatment. In a few instances, aerated lagoons are used for pretreatment of high strength wastewaters before discharge to other treatment facilities.

This presentation will discuss various types of aerated lagoon facilities, their application to specific industrial groups,

and aeration devices currently in use. In addition, performance and operating problems of these installations will be reviewed and recommended design criteria outlined.

DESCRIPTION OF TREATMENT FACILITIES

In describing the physical and process design data associated with these facilities, two categories of aerated lagoons will be considered.

The first general classification is the facultative aerated lagoon, i.e. allowing solids deposition while maintaining a uniform dissolved oxygen concentration throughout the liquid phase. In this system, the settled solids, including biological floc, undergo anaerobic decomposition at the bottom of the lagoon.

Previously, such lagoons had been designed primarily on a retention basis, providing anywhere from 8 to 20 days retention. The other design consideration, oxygen supply, was usually satisfied by providing 1.2-1.4 lb O_2/lb BOD applied.

Table I outlines the physical data associated with these facultative aerated lagoon systems. Table I also includes a column entitled Mixing Turnover Time in Minutes. This parameter is a measure of the mixing intensity within the basin. Its numerical value is calculated by dividing the volume of the basin by the nominal pumping capacity of the aerator. An absolute critical pumping time for complete mixing cannot be determined as these values are a function of the type of aerator. However, for the diffused air systems described in Figure 1, a turnover time of approximately seven minutes should ensure complete mixing of biological solids. From Table I, it can be seen that these systems have turnover times greatly in excess of the critical value, thus ensuring solids deposition.

The other type of aerated lagoon occasionally encountered is the mixed aerated lagoon, sometimes referred to as an aerobic lagoon. Here, a high level of turbulence is provided to maintain all solids in suspension, and thus no organic removal takes place through solids deposition. This is somewhat similar to the activated sludge process without sludge recirculation. The extended retention time allows a "wash-out" level of activated sludge solids to be maintained. Previously, the design of these systems had essentially been based on retention time (up to four days) and satisfying oxygen requirements, again 1.2-1.4 lb O_2/lb BOD applied.

The physical data associated with mixed aerated lagoon installations are also shown in Table I.

TABLE I

AERATED LAGOON PHYSICAL DATA

Type of Waste	Flow mgd	Detention Time Days	Oxygen Design lb/day	Supply Type	Mixing** Turnover Time min
i) Facultative Aerated Lagoons					
A) Domestic (Seasonal Winery)	0.15	8	640	Mechanical	0.05*
B) Chicken Processing	0.18	18	1300	Diffused Air	117
C) Potato Processing	0.75	14	2650	Diffused Air	112
D) Domestic	0.50	8	1430	Diffused Air	76
E) Instant Coffee Processing	0.28	11	1460	Diffused Air	63
F) Fruit Canning	0.13	39	2800	Diffused Air	40
ii) Mixed Aerated Lagoons					
G) Domestic & Milk Processing	0.14	8.8	1170	Mechanical	0.10*
H) Mixed Industrial	0.18	1.2	900	Mechanical	0.57*
I) Mixed Industrial & Reformatory	0.15	3.2	640	Mechanical	0.14*
J) Milk Processing	0.10	12.0	3450	Mechanical	0.27*

* HP/1000 ft^3

$$\text{**Turnover time in min} = \frac{\text{Aeration basin volume in gal}}{\text{Aerator pumping capacity in gal/min}}$$

PERFORMANCE DATA ON AERATED LAGOONS

The loading conditions of the aerated lagoon systems previously described are presented in Table II, with the data being obtained during in-depth studies of each facility carried out over the past several years. These field investigations usually extended over a period of six months to one year. In addition to determining raw waste and effluent characteristics, dissolved oxygen profiles and solids deposition were also measured.

TABLE II

LOADING CONDITIONS

	Raw Sewage			Organic Load		Hydraulic Load	
	Flow	BOD mg/l	Susp. Solids mg/l	lb BOD/ 1000 ft /	% Design	Detention Time Days	% Design
i)	Facultative Aerated Lagoons						
A)	0.15	154	110	1.2	54	8	-
B)	0.18	600	368	1.8	123	18	109
C)	0.75	1200	400	5.3	408	14	125
D)	0.50	145	120	1.2	61	8	83
E)	0.28	540	348	3.2	124	11	93
F)	0.13	1900	236	3.4	102	39	33
ii)	Mixed Aerated Lagoons						
G)	0.14	590	153	3.6	120	8.8	48
H)	0.18	352	214	18.8	85	1.2	310
I)	0.15	166	125	3.6	-	3.2	-
J)	0.10	2360	785	12.7	85	12.0	83

In Table III, the per cent BOD and suspended solids removals and associated effluent qualities for the treatment systems are summarized.

TABLE III

EFFLUENT QUALITY

	Effluent			% Removal	
	BOD mg/l	Filtered BOD mg/l	Susp. Solids mg/l	BOD	Susp. Solids
i) Facultative Aerated Lagoons					
A)	25	20	40	84	64
B)	85	40	56	86	85
C)	1100	800	249	8	38
D)	30	20	50	80	58
E)	266	210	89	51	74
F)	500	400	25	74	89
ii) Mixed Aerated Lagoons					
G)	170	30	160	71	-5
H)	200	75	200	43	0
I)	124	28	220	25	-76
J)	1450	470	2100	39	-168

DISCUSSION

Effluent Quality

The results in Table III indicate that aerated lagoons do not provide a high quality effluent comparable to secondary

treatment. While the degree of treatment is frequently quite high, i.e. good per cent reductions of BOD attained, the effluent is generally similar to that from waste stabilization ponds. With domestic wastes, an effluent quality of 30 to 50 mg/l BOD and SS can be expected from a facultative aerated lagoon. In our studies to date, we have not observed any seasonal fluctuation in effluent quality such as may be associated with temperature or algal effects. This relatively uniform performance could likely be attributed to conservative design parameters resulting in long retention times overcoming any temperature effect.

<u>BOD Removal</u>

A) Facultative Aerated Lagoons

The mechanism of organic removal through aerated lagoon systems warrants consideration. In a facultative system, the three significant removal mechanisms are sedimentation, biological and chemical oxidation. Bottom sludge surveys have indicated that extensive solids deposition does take place. The biological or biochemical removal appears to take place through a bacterial rather than an algal system.

Dissolved oxygen traces have indicated that the DO concentration follows the applied BOD load; as the hourly BOD applied increases, the DO decreases. In an algal system, the DO generally responds to light intensity rather than the applied organic load.

With such varied organic removal mechanisms, perhaps interrelated, the design use of an overall removal rate constant is problematical. Such rate constants are generally associated or should be associated with the soluble BOD and thus ignore BOD removal by sedimentation. However, rate constants may be obtained from laboratory or pilot data and then used in an empirical plant design. In the design of aerated lagoons, the use of a volumetric organic loading factor likely has greater applicability than generalized rate constants. Field observations have indicated that at an organic loading factor of approximately 2 lb BOD/1000 cu ft/day, an acceptable effluent quality may be expected.

B) Mixed Aerated Lagoons

Because of the high levels of turbulence associated with these systems, no BOD removal by sedimentation is encountered.

Thus the remaining mechanisms for organic removal are chemical and biological oxidation, usually accompanied by synthesis of bacterial mass. With the high turbulence levels in these systems, the sludge age is essentially the hydraulic retention time. In the mixed systems G) and J) in Table II with retention times of 8.8 and 12 days respectively, a flocculant activated sludge type of solids was produced. In a settling test, these solids settled readily leaving a reasonably clear supernatant associated with high BOD removals. However, in systems H) and I) when the retention time is only one to three days, the lagoon effluent contained little well-settling flocculant material and the settling test supernatant was quite turbid. The dispersed nature of the sludge produced is likely a result of the low (1 - 2 day) sludge age associated with these systems.

For aerated lagoon considerations, there does not appear to be any merit in providing a completely mixed system unless a clarifier is provided to increase the effective sludge age, thus providing a sludge with flocculant characteristics. The system then becomes a low rate activated sludge process. Without the clarifier, the total effluent BOD will be considerably greater than that from a facultative aerated lagoon, with the major portion of the effluent BOD due to the suspended solids. This is illustrated by the BOD and filtered BOD data in Table III. In cases where a stabilization pond follows the mixed aerated lagoon, the discharge of high solids to the second pond may create a rather severe odour problem. Again, the applicability of such a mixed aerated lagoon system appears questionable, unless future conversion to the activated sludge process is anticipated.

Aerated Lagoon Attributes

Some of the advantages of facultative aerated lagoons are:

i) Lower operating and capital costs than conventional activated sludge process.

ii) Ability to handle high-strength wastes.

iii) No associated sludge disposal problem.

iv) Raw waste pretreatment requirements minimal.

v) Low level of operator skill required.

However, there are certain obvious drawbacks to the use of aerated lagoons:

i) Effluent quality not comparable to that obtained from activated sludge process.

ii) Land requirement is greater than that for conventional activated sludge process.

Aeration Devices

The surface aerators commonly in use are either pier mounted or floating units having the same action as those found in activated sludge systems.

For subsurface aeration, both air gun and perforated tubing systems are in use. Considerably less maintenance has been associated with the air gun system than the perforated tubing.

In any case, the equipment selection depends upon the economics of the situation, but may also be influenced by the mixing requirements and ambient temperatures.

Lower capital and operating costs are normally associated with surface aeration devices.

PROBLEM AREAS

With facultative aerated lagoons, a minor problem that has been observed is floating sludge. During the spring warm-up, masses of anaerobic sludge may periodically rise to the surface not only yielding a poor effluent but also causing a considerable odour problem. If surface agitation is great enough, this fragile sludge may be quickly dispersed with minimal problem.

Berm protection is required and may be provided by concrete, asphalt or rip-rap.

In all aerated lagoon systems, grit, rag and debris removal should be provided to minimize long-term operating difficulties.

Reliable performance of aeration devices, either surface or subsurface, has at times been a significant problem in the operation of these installations.

No mechanical problems have been associated with winter operation of lagoons using subsurface aeration devices. With proper design, icing has not been a problem with surface aerators. Proper design includes adequate clearance, both horizontal and vertical, between aerator and both pier and platform.

DESIGN CONSIDERATIONS

In general, aerated lagoons may be used for treatment of degradable industrial wastes providing toxic effects are not exhibited.

Perhaps the major process limitation with the use of aerated lagoons is the fundamental problem of getting a high strength waste down to a secondary or acceptable effluent quality in one single stage treatment unit. In treating industrial wastewaters, this problem becomes even more acute; as this usually involves removal efficiencies in excess of 95%, it appears unrealistic to expect such performance from single stage aerated lagoons. In the past, there has been a reluctance to design multi-stage aerated lagoon systems for the treatment of high strength industrial wastes. This reluctance has led to single stage systems such as C) and F) being misapplied. Where BOD removals in excess of 90% are required, multi-stage treatment facilities should be considered.

For discussion purposes, aerated lagoon design considerations have been divided into two general categories.

i) High strength wastes - e.g. chemical, some pulp and paper, brewery, distillery, food processing.

When raw waste BOD values are in excess of 1000 mg/l, it may be advisable to precede an aerated lagoon with a high intensity aeration cell, i.e. operating at a high volumetric organic loading. The sludge produced may have either flocculant or dispersed growth characteristics depending on the retention time (sludge age). However, it is essential that treatability studies be conducted to ensure proper design of a multi-stage system.

ii) Intermediate strength wastes - e.g. textiles, refinery, pulp and paper, petrochemical, and domestic.

With these types of wastes, a single stage facultative aerated lagoon should produce an acceptable effluent.

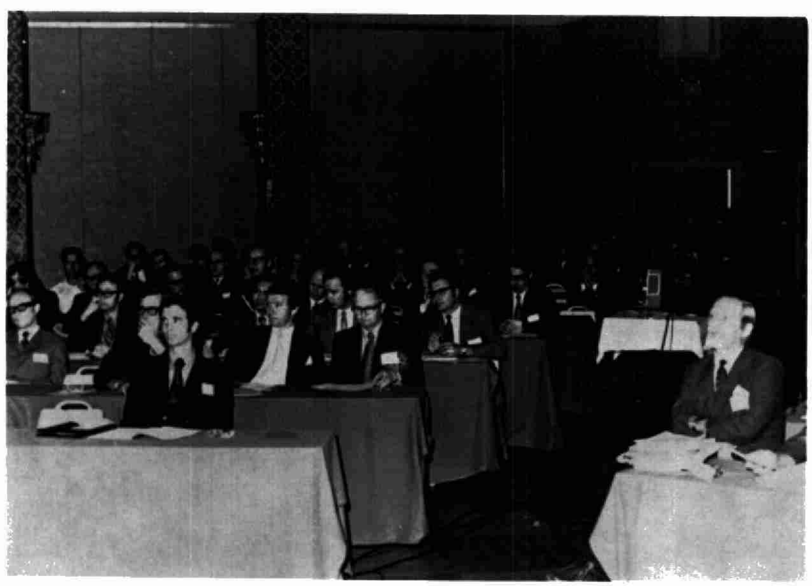
For design of facultative aerated lagoons, a volumetric organic loading of 2 lb BOD/1000 cu ft/day should provide an acceptable effluent quality. If an attempt is made to design a facultative aerated lagoon at higher volumetric organic loadings, care should be taken to avoid the high mixing conditions that may result from satisfying the associated oxygen requirements. When considering single stage aerated lagoons, facultative systems are to be preferred over mixed systems.

For industrial waste treatment facilities, or systems treating mixtures of domestic sewage and industrial wastes, it is essential that some indication of biodegradability and/or treatability be determined. Frequently such information can be obtained from the literature; otherwise tests of a continuous feed nature with parallel investigations to determine nutrient requirements should be conducted. During these tests care should be taken to ensure a representative sample of the expected waste is used.

Introducing Mr. Robert Johnston, recently-appointed Chairman of the Ontario Water Resources Commission ....

.... during a busy period on the Registration Desk.

Delegates attending a technical session in the Grand Ballroom ....



....

at the Banquet,
introducing the
Head Table

Speaking to the Banquet
- Dr. James Ham,
University of Toronto

....

....

delegates and
wives attending
the Banquet

SESSION CHAIRMAN,
MR. JIM HOOPER,
CITY ENGINEER,
CITY OF PETERBOROUGH,
PETERBOROUGH, ONTARIO.

L.S. Romano

"IMPLEMENTATION OF INDUSTRIAL WASTE CONTROL, CITY OF WINDSOR"

BY

L.S. ROMANO,
DIRECTOR OF SEWAGE TREATMENT

R.T. BAILEY,
COMMISSIONER OF WORKS

CITY OF WINDSOR,
WINDSOR, ONTARIO.

HISTORY

(a) The pre-annexation portion of the City (1965) flowed directly into the Detroit River.

(b) The southern suburbs, now Wards 7 and 8 were all residential or commercial; they were served by two small contact stabilization plants and the rest were on septic tanks.

(c) Windsor, following annexation in 1966, had a secondary sewage treatment plant located on and serving the east side of the City with only one large automotive industry connected to it. The problems in connection with this industry were easily handled by the operating staff of the Little River Sewage Treatment Plant.

(d) Industrial waste lagoons at the Western Sanitary Landfill accepted all industrial waste that was hauled there.

(e) Pollution control was enforced by the O.W.R.C. and to some extent by the Public Works Department, the Building Department and the Metro Health Unit. On September 1, 1969, a sewer-use by-law (Number 3441 of the City of Windsor) came into effect. This was to coincide with the completion of the West Windsor Sewage Treatment Plant and the equipping and staffing of the laboratory in the Fall of 1969.

SEWER USE BY-LAW

The Sewer Use By-law is modelled along the guidelines given in the O.W.R.C. booklet "Industrial Pollution Control in Municipalities."

Early in 1966 municipal officials met with industry of the City. A series of meetings took place for the purpose of drawing up regulations as to sewer and sewage treatment plant uses.

It was generally agreed that the Municipality should accept and treat all liquid waste, originating within the tributary area, which does not cause damage to the sewers or affect treatment plant operation. A survey of the industrial contribution of amenable waste was taken, as the City wanted to provide a maximum use of the proposed municipal sewage treatment facilities to industry, while still providing the control that is necessary to protect the treatment works. Since the City-wide B.O.D. average was going to be very low due to dilution, blending, and other factors, a B.O.D. limit of 500 m.g. per litre and suspended solids of 600 m.g. per litre was set, to accommodate high B.O.D. industrial wastes within the Sewage Treatment Plant design limits.

STAFFING OF POLLUTION CONTROL - LABORATORY GROUP

It was realized at the outset by the Commissioner of Works, that a continuous concentrated effort would be required to bring industrial pollution control into effect. Since the operating section of the Sewage Treatment Branch would be fully occupied with the start-up of a new plant and over-all operational problems, a separate division within the Sewage Treatment Branch was set up, called the Laboratory and Pollution Control Division; this Division reported directly to the Director of Sewage Treatment. The chemist, or the pollution control officer would head up this group.

The applicant chosen as the chemist was a microbiologist with excellent supervisory experience and some industrial waste background. In addition to pollution control, the chemist and the laboratory staff were scheduled to undertake in-plant studies such as nutrient removal and the like. The Director, being familiar with industrial waste problems, would assist the chemist as required. The chemist was to have three persons to assist him, viz. a working foreman and two technicians. Even though this was a small group, a foreman was thought to be necessary for the following reasons:

(a) The group would often be split with two on field survey and two in the lab. Therefore each group

should have a person in charge with responsibility. This was especially true in survey work in industry, here the City could assure itself that supervision was always available.

(b) The foreman would be available as a Corporation witness in court cases if required.

(c) During absences of the chemist, daily work could carry on unimpeded by lack of supervision, as the Director would not always be available.

An excellent foreman with extensive industrial waste experience both in the United Kingdom and Canada was hired in September of 1969, (but wage rates of the automotive industry lured him away less than a year later). In looking at the requirements of the technicians, it was decided that the applicants must be in (a) good health, (hard work such as opening manholes, climbing in and out of sewers, etc.), (b) technical knowledge required should be at least a C.E. Technician Certificate, a Technologist Degree was preferable, (c) a chauffeur's licence was required. In the newspaper advertisements a Technologist was specified as a minimum or a Technician with experience.

We have, to date, been fortunate in acquiring three good men, two with a B.Sc. degree, one of which is now the foreman; the other, a Technologist from the local community college. This calibre of person requires a minimum of supervision, acquires the necessary skills quickly, can offer valid suggestions and usually shows considerable self-initiative.

INDUSTRIAL WASTE LABORATORY EQUIPMENT AND COSTS

The following is the major list of equipment primarily used for Industrial Waste:

(a) An atomic spectrophotometer - used primarily for the heavy metals. This instrument was required because of the quantity of samples to be run and the sensitivity required.

(b) A colorimeter, spectronic 20 - this is used for analysis of nutrients such as phosphate: other foreign elements such as cyanides; phenols; metals; and nitrates.

(c) A D.O. meter - this is used to take B.O.D. readings on spot checks throughout the City.

(d) Portable recording pH meters - these are semi-waterproof combination electrode type with extension leads.

(e) Portable samplers of several types of manufacture. These samplers are adaptable for a sewer manhole and have variable timers. A new sampler is on order which will take individual samples on an hourly basis.

(f) Flow measurement meters - adjustable weirs from 6" to 36".

(g) Portable plastic flumes from 6" to 12".

(h) Recording water level indicator and a current meter.

(i) Safety testing equipment for gases and oxygen deficiency.

The total cost of the above equipment was in the order of $10,000. The laboratory furniture, fume hoods, balances, microscopes, etc. were in the order of $40,000. Note should be made here that if a lab is to run extensive B.O.D. samples, a laboratory model dishwasher is a "must"; unfortunately such a model was not specified for our laboratory.

INITIAL HELP FROM OTHER AGENCIES

Numerous pitfalls were avoided and a considerable amount of time was saved in getting the pollution control programme into operation by seeking the assistance of several groups, notably the O.W.R.C. Division of Industrial Waste and the City of London Sanitary Engineering Branch.

Several days were spent in Toronto at the offices of the O.W.R.C. acquainting City personnel with the methods and procedures used by the O.W.R.C. It was extremely fortunate that the City of Windsor was invited to attend the first Industrial Waste By-law Enforcement Course, sponsored by the O.W.R.C. and the City Engineers' Association Advisory Committee. At the course, various problems of industrial waste were given, varied methods of sampling, flow measurements and specific ways of conducting industrial waste surveys were given. Good rapport was obtained amongst other municipalities on mutual problems.

We may add that this Course was invaluable for a starter and would recommend it to any municipality starting off on pollution control.

A review with the City of London personnel of their methods, procedures and testing equipment was extremely advantageous. They had been in this field for several years and the knowledge gained from their experience and suggestions was greatly appreciated.

Surveys done of the Windsor area by the O.W.R.C. in previous years especially in 1968, were also of assistance in setting up priorities as to which industries should be surveyed first, and what equipment and methods should be used.

PROBLEMS IN IMPLEMENTATION OF POLLUTION CONTROL

Each city will have its own particular problems initiating industrial waste control and the following are some of the problems experienced in the City of Windsor. For your benefit some general background might be in order. The City of Windsor is highly industrialized and has four major, distinct industry categories: (1) Automotive Components and Assembly Plants including foundry and metal-working plants; (2) Metal Electroplating; (3) Food Processing Industries such as meat packing, fermentation, dairies, food preparation and packaging, and soft-drink bottlers and of course (4) a host of other industries such as pharmaceutical, paint, salt, etc.

Most of the City's industry is located in the pre-annexation core city (Wards 1 to 5). This area is now served by the West Windsor Sewage Treatment Plant. However a new industrial park is now complete on the east side of the City and the area is served by the Little River Sewage Treatment Plant which is an activated sludge process, which until recently had only one industry discharging into it.

The core city, as mentioned previously, had sanitary, combined, and storm sewers flowing directly to the river. Both the sanitary and combined sewers have been intercepted by a riverfront interceptor sewer at 28 locations. Underground interceptor chambers have been constructed at these locations, which serve as an excellent composite sampling spot for the area of the City that is being discharged to that chamber. The West Windsor Sewage Treatment Plant came on stream shortly after the laboratory was staffed and equipped, and it soon became apparent from tests at the Plant and the interceptor chambers, that pH was the first problem to be tackled, toxic metals from the metal plating industries, second.

pH

The pH problem was acute in the area served by Interceptor Chamber (W), near the eastern upstream extremity of the Riverfront Interceptor Sewer. The Interceptor Chambers

and interceptor sewer are constructed of concrete and within six weeks after the chamber had been in use, a noticeable amount of concrete had been eroded. Upstream it was known that a section of approximately 2,000 feet of a concrete box sewer had no invert. This sewer had been replaced in the late 40's, because the old one had collapsed. The portable pH meter was installed in the chamber and only once in five weeks did it show a pH of less than 1.5 for the total flow in the chamber. However, the City at the time had only one portable recording pH meter and since it had to be recharged every second day continuous readings could not be taken. An additional meter was requested along with batteries so that the two meters could be kept operating continuously if required to pin-point the local sewer draining into the Trunk serving this grid.

In the meantime a quick survey was taken of all the plants in the area. Several were found to have pickling systems, and all were served locally by vitreous clay sewers. Therefore no immediate damage was noted to the sewer at any one plant. All the industries were asked if they neutralized their acid before dumping, or if it was disposed of by others. They all stated that the acid was neutralized.

It was then decided to ask each of the five industries exactly how the pickle acid was neutralized, while this work was underway samples were taken of their process and analyzed for the iron, and other metallic ions.

On visiting the responsible party involved, to determine how their acid was neutralized and what was done with the sludge, it was found that the acid was "neutralized" when it was "spent" or slow to pickle, and then the 8,000 gallon tank of 93% sulphuric acid was opened to the sewer. This was done approximately every seven or eight working days.

This points out more than ever that the pollution control group must be aware of all the industries on the sewer system, their products, their methods, and their personnel. This is a fairly large plant, a subsidiary of a large Canadian Corporation; however there was no one on staff with any chemical background. It was also found that besides the pH problem, one of toxic zinc metal existed since occasionally the tanks would be used as strippers for rejects from the galvanizing department. It was found that many industries did not know the meaning or effect of acids and alkalies on the pH of their effluent to a sewer stream. Even suppliers of cleaning solutions, e.g. boiler cleaning, were selling muriatic solutions of 10% to 25% and then telling their customers that when dumping the acid anywhere from 3,000 to 5,000 gallons at a time to "just turn

the fire-hose on" for dilution. pH fluctuations were varying from 4.0 to 12.8 for the total flow entering the new West Windsor Sewage Treatment Plant. This range would be seen at least once in a forty-eight hour period. This, of course, causes extensive damage to plant equipment and sewers. The high and low for the early months of 1971 were 5.8 and 10.0 and the low reading took place only once, and the high reading only twice in fifty-five days. However, this still points out much more surveillance of the local industry and education must be done.

The present by-law sets a lower pH limit of 5.5. The laboratory is presently testing concrete samples in buffer solutions in this range. If 5.5 is shown to be too low we shall request it to be raised to 6.0.

Several industries in 1970 were found liable for damaging local sewers, and have paid for the repair. One case is presently in litigation.

METAL ELECTROPLATING PLANTS

Waste generated from this industry is toxic and must be handled with caution whether discharging to a water-course or sanitary sewer. The pH problem consists of batch dumps of acids and alkaline solutions; also cyanides, grease and oil are found in these wastes. The total metal loadings, made up of the ions of chromium, zinc, copper, nickel and cadmium discharged to City sewers were found to be over 200 pounds per day. At the time of writing, all the electroplating firms in the City have been surveyed. At present over $400,000 of pollution abatement equipment is being installed by this industry. This, coupled with work done by the O.W.R.C. previously with electroplating plants discharging into storm sewers or water-courses, will bring this total to over $850,000.

In this industry, generally, the Department received excellent co-operation. Although no two industries installed exactly the same equipment, the Department of Public Works co-operated with some of the electroplating firms to eliminate poor designs or firms that were more interested in selling equipment than really helping the industry to reduce its pollution load, in an effective and economical manner.

Here again several small firms having electroplating facilities were found by detecting cyanides or metal ions in random samples taken in city sewer checks. Some of these firms - which were listed as just hardware suppliers - were discovered to be periodically dumping acids, while their normal plant effluent contained a very high excess of cyanide.

This could have been disastrous as the Department had crews working in the sub-trunks serving the local sewer, which was from a supposedly residential-commercial district. This again points out the necessity of knowing the City and particularly all the potential discharges into the sewer.

OILY DISCHARGES

In this category fall most of the automotive suppliers - subsidiaries of the big three automobile manufacturers - the tool and die firms and small manufacturers of machines such as lawn-mowers, etc. Also included here are industries that use oil for heating or fuel such as the railroads. In the manufacturing industries, the loading is mostly organic, from paint spray booths, part washer effluents, and bonderite rinse wastes. Generally these supplier industries were initially co-operative, but many have failed to carry out the needed works to adequately remove this oil. Some industries took half measures in an attempt to economize on the solution to their problem. In most cases higher management disregarded advice of their plant engineers. In one case, cost accountants of a large technically competent company completely quashed recommendations drawn up by the plant engineers. This corporation's main problem was oil discharge from parts washers. The accountants merely ordered "biodegradable alkaline cleaners", and installed a single replaceable cloth screen to filter the 99% emulsified oil as it was sewered. Needless to say they have been re-instructed to provide an adequate oil removal system.

A major problem in this field is education; it is extremely difficult in many cases to explain that emulsified oils or most coolants contain oil as damaging as any lubricant.

The big three auto makers in Windsor working along with the O.W.R.C. have now all installed complete oil removal waste treatment plants. These plants are some of the most modern on the North American continent. The City of Windsor is proud to have these complex technical plants demonstrating that pollution in this technical age need not be a by-product of progress. Visitors from throughout the world have come to view these waste removal plants.

Since the pollution group was established, Windsor has, unfortunately, experienced several major oil spills. In these situations, to trace the oil quickly to the source, it is very important to know the City - have available detailed sewer maps, and have a well-equipped laboratory mobile van from which the pollution control group can work. Quick action is necessary in these large spills, because in most

the source is unaware of its loss, and/ or not aware of the quantity per time being lost. Also if the oil loss be through a storm sewer as is often the case, the receiving stream can be blocked off and 99% of the oil recovered. The Operations Branch of the Public Works Department has been most co-operative in working with the Sewage Treatment Branch in every instance where oil was lost in a creek or stream. They have made it a top priority to move in whatever equipment, material, and manpower is required to trap and remove the oil.

The immediate tracing of the oil is very important. Two pollution control crews in two trucks should start leap-frogging from manhole to manhole tracing the oil upstream. Meanwhile a third crew, if possible, (in our case usually the Director and Chemist) quickly review the area served by the discharging sewer and if possible certain industries and/or strategic manholes are inspected. The pollution control group now has come to expect the unexpected, in tracing a discharge. Invariably it has been a totally unpredictable source, or private sewer connected years ago to the City system, of which no known records were ever made. In most cases, although arduous (and time-consuming) for the laboratory crew, tracing upstream manhole by manhole was the only way the source was found.

This is a good time to bring in the desirability of having a camera always available to the pollution control group. Usually in accidental spills or discharges it is not possible to obtain a professional photographer, when and where desired. The laboratory has purchased a small relatively inexpensive camera that can take good colour pictures. It has a close-up focus, uses flash-cubes, and has an electric eye for daylight pictures. This camera, used strictly by non-photographers, has been invaluable in taking pictures inside sewers (as well as outside), and even pictures of private sewer laterals. As extra evidence, in many cases, the photographs clinched the case. In all the major oil spills to date the source was found, and the offending party either paid for the total cost of recovery and cleaning of the stream, in one case prosecution under the O.W.R.C. Act is pending.

In all these cases the O.W.R.C. was immediately informed and they have been invaluable in analyzing the samples taken by us through an infra-red spectrophotometer in order to have indisputable evidence; and in their technical assistance in the recovery of the oil from the streams.

COMMUNICATION

The emergency situations have clearly demonstrated that immediate and continued communication is essential between the pollution control centre, and the crew on the laboratory van as well as other crews that may be sent out. Therefore a base radio has been acquired at the pollution control centre, for the pump-houses, and also for industrial pollution control. This year the laboratory truck will become radio-equipped.

CLOSING OF THE LANDFILL AND ILLEGAL DUMPING INTO MANHOLES

As mentioned previously, Windsor, as did many municipalities in Ontario, maintained "lagoons" at the Western Sanitary landfill for the discharge of industrial wastes up to September of 1970. In spite of all efforts the surrounding ground was saturated with oil and on many occasions the creek serving the area was contaminated with organics. In the meantime a private disposal facility was established in the City, which was able to handle the waste generated in the Metropolitan Windsor and Essex County area. The landfill was then closed to industrial waste in September of 1970 and all the oil in these "lagoons" was hauled to a disposal company.

Shortly after the closing of the landfill the City began to experience a great deal of difficulty in illegal dumping into various sewer manholes throughout the City. Even the Eastern Sewage Treatment Plant, basically serving a residential area, was receiving slugs of oil, pickle liquor, and septic wastes. On two occasions the secondary activated sludge plant was almost lost. This plant has new main trunk sewers extending out to subdivisions that are just being developed. This afforded the miscreants manholes a good distance from local citizen scrutiny. Oil concentrations also increased at the West Windsor Sewage Treatment Plant.

Additional manhole samplers were ordered to try to pin-point the dumpers, however this was going to take some time to receive, and even then it would be a cat and mouse game, with the trucker having most of the initiative.

In an attempt to alleviate the situation quickly the following steps were taken:

(a) City Police were requested to maintain extra vigilance on any tank trucks parked on City streets during the evening hours.

(b) The newspaper, radio and TV media were used to inform the citizens of Windsor of the situation and to ask them for their co-operation in reporting these illegal dumping actions.

(c) The Waste Management Branch was asked to assist the City Pollution Control Branch in interviewing certain trucking companies and industrial establishments to determine if industrial wastes were being properly handled. The above-mentioned groups were most co-operative, and extensive coverage was given in all the communication media.

Almost immediately the dumping stopped. No slugs of industrial waste affected the eastern plant until last month. We do not believe a full resurgence of dumping will occur. However, the sewage treatment branch lives in the constant state of apprehension that a heavy slug from an illegal dump will take a plant out of commission or cause heavy damage.

To this end, we feel that all truckers should be licensed by the Province and each load leaving an industrial establishment should have to be reported and recorded by the industry, the trucker, and the disposal facility, with copies to the Waste Management Branch. The average oil level in parts per million in the influent to the West Windsor Sewage Treatment Plant has decreased considerably in the past year, having been cut by half, however considerable work is required to bring it down to an acceptable level.

Grease traps in institutions throughout the City are postulated to be contributing a significant portion of the total grease. In spot checks on these installations it has been noted that the majority are by-passed or circumvented in their function. To police this facet of pollution additional staff would be required and no final decision has been made to date.

SEWER CHARGES AND THE FOOD PROCESSING INDUSTRIES

Industries covered in this category are those engaged in the production of edible goods for human consumption. Food processing wastes are essentially organic in nature and hence are normally amenable to treatment in municipal facilities. However, as most of this industry is located in the old core city and most of its discharge wastes contain high concentrations of colloidal and dissolved solids, which are not removed by simple sedimentation; therefore the wastes in this category have a marked effect on the effluent leaving the western treatment plant. The Public Works Department is now in process of surveying this category of industry. As each individual survey is done, the need for in-plant control, and pre-treatment of waste is pointed out. Until the whole industry is surveyed no policy will be made as to the limitations or surcharges that might be levied to the industry generally. One major problem in applying a surcharge, is that sewage treatment

in the City is costed on the general tax rate. Therefore no penalty is applied on the dilution factor. A food processing industry that is using a large amount of water in its production process and has a high BOD level has little incentive to reduce its water consumption, as this would tend to increase the BOD concentration and thereby increase the potential surcharge. On the other hand, a very small industry with average BOD load and little process waste water would have a relatively high surcharge compared to the first industry. Our problem is to work out an equitable system where "dilution is not a solution to pollution". The fermentation industry located in the Walkerville section of the City has done much work in conjunction with the O.W.R.C. and the Municipality in isolating process streams, and removing clean cooling water from the sanitary waste. This has removed the waste from the Detroit River as well as reducing the hydraulic load on the municipal plant. Oil and pH problems were also brought under control.

SUMMARY

Industrial pollution involves the detailed inspection of processes and operations which generate liquid waste. In the Municipality of Windsor such surveys are approached in three stages:

(a) Pre-field survey.

(b) Field survey.

(c) Post survey.

The Director of Sewage Treatment and the Chemist contact the various industries and commercial institutions at the decision-making level. At such a meeting, sampling station locations are established from which samples of the plant effluent are collected during the field survey work. The duration and extent of the sampling period depend on the consistency of plant operations and the type and volume of wastes generated. The analytical data from the analyzed samples are carefully examined before a report is prepared and submitted to the company. In any area in which the plant discharges wastes which do not meet the conditions as stipulated in the Sewer Use By-law, the company officials are asked to submit to the Commissioner of Public Works a reasonable time-table showing the anticipated installations of effective abatement equipment. The follow-up procedure used is an inventory card system maintained on each industry. The card indicates outstanding work to be done, - and the frequency of re-survey required, and evaluations of spot-checks.

Industry, generally, has been very co-operative. Much has been accomplished, although considerable work remains to be done. The Municipality is progressing well on the path of pollution control. Problems arising from the waste of a particular company are discussed in meetings between the City of Windsor, company officials, and if necessary, representatives of the O.W.R.C. This ensures a thorough understanding of the problem and usually mutually satisfactory solutions eventually emanate.

Effective pollution control with its resultant benefits to the health and welfare of the present and future generations, will result only from the mutual co-operation between industry and concerned pollution control agencies.

D.A. Lazarchik

"PENNSYLVANIA'S POLLUTION INCIDENT PREVENTION PROGRAM"

BY

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The pollution incidents that are the topic of my discussion are _not_ the result of the normal day-to-day waste discharges from industrial plants. Such day-to-day operations may cause degradation of stream quality and restrict water use, but these situations can normally be controlled by vigorous enforcement of existing law and are not what we refer to as pollution incidents. Rather, we are concerned in the Pollution Incident Prevention Program with the acute pollution situation that often occurs on a stream that is of reasonably good quality and is used for various beneficial purposes. In many cases, we are concerned with a small stream used for fishing, recreation, and water supply that happens to pass by an industrial operation of some kind.

A series of major spills and pollution incidents causing serious damage to water use in Pennsylvania occurred during the late 1960's. These were by no means the first such incidents to occur in the state, but the severity and the timing of the incidents focused a great deal of public attention on the inadequacies at that time in Pennsylvania's Clean Streams Law to _prevent_ spills whether they are accidental or not.

Pennsylvania's stream uses often have been damaged by minor spills and accidents. During the 1940's as the Pennsylvania Sanitary Water Board began to move ahead with the enforcement provisions of the Clean Streams Law, many small industrial plants turned to the use of earthen lagoons as a means of avoiding control by the Board. The law gave the Board control over the discharge of wastes but it did not prevent many plants from retaining wastes on the plant property by digging holes in the ground. The use of such lagoons or wastewater impoundments in most cases simply postponed the day of finding an ultimate solution to waste handling. The lagoons were usually designed and constructed by a bulldozer operator. Tree trunks, boulders, and porous fill material were readily available and often found their way into the lagoon embankments. These lagoons caused air pollution problems and public health nuisances. Some of them drained through porous soils to ultimately pollute ground water. Some overflowed their banks; especially at night and on weekends and holidays. Lagoons have been responsible for more acute stream pollution situations than any other waste treatment or abatement device in use in Pennsylvania.

While we had long been aware of the problems caused by lagoons, and had been frustrated by our lack of authority to control them, lagoons were by no means the only cause of acute pollution situations in Pennsylvania. Nevertheless, a series of lagoon failures pointed out the need to control this and other sources of spills, and late in 1968 the Sanitary Water Board took action to encourage industry in Pennsylvania to accept its legal and moral responsibility to avoid pollution incidents. The Board's regulations have, for many years, stated that whenever any toxic or taste and odor producing substance or other substance which endangers downstream users of water is discharged, it is the responsibility of the person in charge to immediately notify the Board. It was also his duty to immediately take all practical steps to prevent injury to property and to downstream water use. The Board's regulations also stated that the retention of wastes of a polluting character on private land was the responsibility of those in control of the wastes. They must see to it that retaining structures are maintained in sound condition to prevent the loss of the wastes through carelessness, or maliciousness, or through the action of animals or the hazards of weather. Failure to maintain the structures renders the parties in control liable to the prescribed penalties of the law. As you will see from the remarks that I will make during the next few minutes, these regulations did not prove effective in preventing spills, accidental discharges, and the resulting pollution incidents.

A review of pollution incidents that occurred in Pennsylvania during a 7-year period indicated that there were

at least 496 accidents, spills, or intentional dumping of pollutional materials to Pennsylvania streams. 71 incidents a year were by no means the only spills and accidents that occurred. The 71 incidents per year represent spills that were serious enough to kill fish and were noticed by someone and reported for investigation by the Board. These incidents do not necessarily include the hundreds of occurrences of tastes and odors in public water supply, the temporary discoloration of receiving streams and other adverse effects that may not be severe enough to kill fish.

The largest single source of the incidents was equipment failure or breakdown in industrial plants. In most cases such equipment failure was not associated with an industrial waste treatment plant but with failure in manufacturing or process equipment. These failures involved a variety of industrial operations and included broken pipelines in chemical plants, leaking tanks, spills of solvents and caustics, loss of lubricating or hydraulic oils, failures in condensers, dismantling of refrigeration equipment and discharge of ammonia to storm sewers, overflowing of plating waste tanks, faulty pressure gauges and valves, pump breakdowns, power failures, operational errors, corrosion in acid transport pipes, explosions and fires, and even mistakes in making plumbing connections at new manufacturing facilities where separate waste and storm water sewer systems serve the industrial plant.

A second major source of pollution incidents at industrial plants occurred at industrial waste treatment facilities. Bypasses of waste treatment facilities, inadequate treatment because of equipment failure, and overloading of treatment facilities caused a significant number of the pollution incidents in Pennsylvania.

A large number of the fish kills and taste and odor problems were caused by transportation accidents. Over a 7-year period 46 such accidents, or about 10% of the total, were caused by crude oil or petroleum pipeline breaks, by highway accidents involving tank trucks transporting a variety of chemical materials, by construction work and by railroad and waterway transport accidents.

A somewhat smaller number of incidents was caused by the discharge of toxic wastes to municipal sewage systems that receive wastes from industry. This, combined with inadequate sewage treatment, including over-chlorination of treated sewage effluents, caused somewhat less than 10% of the pollution incidents.

Fuel oil handling caused a large number of pollution problems. The overflow of fuel oil storage facilities during delivery, corrosion of underground fuel tanks and

lines, and explosions, caused about 6% of the incidents.

Spills or improper use of pesticides caused 5% of the incidents. Other agriculture-related incidents, including silo drainage, bring the total to 6%.

The disposal of industrial wastes by contract waste haulers and lagoon breaks at other industrial waste disposal sites were responsible for 4% of the incidents.

A variety of other causes, including leachate from sanitary landfills, wastes from the cleaning of water supply mains, sewer line breaks and the natural occurrence of low concentrations of dissolved oxygen because of pond and reservoir turnover or drainage from swamps, accounted for the remaining sources of pollution incidents. The causes of 22% of the incidents could not be determined by our staff, generally because of late notification that the incident occurred.

During a typical two month period in 1970, the following incidents occurred:

Five pipeline breaks involving crude oil
Five motor truck and railway accidents involving naphtha, gasoline, fertilizer, detergents, phenols, acetone, and automatic transmission fluid
Three breakdowns at industrial waste treatment plants involving wood pulp, limestone silt and iron ore tailings
Five fuel oil transfer or storage spills or leaks
One gasoline storage leak

The severity of damages from pollution incidents varied from the death of a few thousand fish valued at a few hundred dollars to the death of a billion fish from a single abandoned mine drainage flushout caused by unbalanced rainfall in the coal mining watersheds of Pennsylvania. Industrial and public water supplies have been curtailed and law suits have resulted. Boat owners have suffered clean-up costs from oil spills. Other recreational uses have been damaged. It is impossible to place an accurate price tag on the total damages caused by pollution incidents.

Several recent major pollution incidents are worthy of mention. Hundreds of thousands of gallons of toxic drilling mud was stored in an earthen lagoon on the Kettle Creek watershed as a result of deep well drilling for natural gas. The lagoon broke just before trout season opened a few years ago and wiped out the entire fish population for 15 miles.

On Brandywine Creek, a railroad employee laid a diesel refueling hose across the main line tracks and was unaware that a passing train had severed the hose. The fuel oil that was lost not only caused a fish kill but shut down a nearby public water supply.

An oil refinery sludge lagoon that had not been used for many years presented a potential pollution threat. New ownership at the refinery responded to our request to abate the threat by filling in the lagoon, only to cause an overflow and embankment break that killed 4 million fish, and caused great mounds of foam on 75 miles of the Allegheny River, in addition to closing several industrial plants that rely on the river for process water.

A power failure at a chemical plant made it necessary to dump reactive materials on the surface of the ground. The alluvial soils quickly transported the toxic materials to French Creek where swimmers left the water because the creek smelled like vinegar and irritated their eyes. $15,000 worth of fish were also killed. In addition to these surface water incidents, we also experience a significant number of major problems of ground water pollution from the storage of chemical wastes, and from petroleum product storage leaks.

Now that you understand what we mean by "pollution incidents", the next question to ask is -- "what can we do to prevent such incidents?" Until August of 1970 Pennsylvania's Clean Streams Law was not oriented toward the prevention of water pollution. Our authority to abate pollution began after the fact.

The control of water pollution was based on a waste discharge permit system, and prior approval by the Sanitary Water Board for the treatment and discharge of wastes. Using its discretionary powers, the Board in 1970 began requiring high risk permittees to prepare and submit pollution incident prevention plans.

An effective Pollution Incident Prevention Plan should include a review of overall plant design and external factors, and a review of plant operations including transportation, storage and processing of raw materials and products. The plan must also include a review of past incidents, a proposal to prevent recurrence, and proper contingency arrangements for notification and clean-up of future incidents.

In the area of plant operations we feel that special attention should be devoted to receiving, transporting and storing of liquids. Routine inspection and preventive maintenance programs should be included for all raw, intermediate and finished product storage and for fuel tanks, storage containers and wastewater impoundments. The direction of flow of spilled liquids is predictable and steps to prevent loss might include the provision of curbs or dikes, the sealing of floor drains and storm water inlets, or the installation of impounding facilities and stop gates between the plant site and nearby water courses. Bulk storage of solid materials in outdoor locations, should be designed to exclude surface

water runoff. Security precautions should be developed for storage areas for hazardous materials and such areas should be routinely patrolled and an inventory maintained.

The effects of the breakdown of mechanical treatment plant equipment should be considered and the availability of spare parts should be determined. Duplicate units should be provided when it is not feasible to shut down the manufacturing process that produces the wastes. Spare parts should be kept on hand for installation in cases where shutdowns of short duration can be tolerated. If it is feasible to shut down the manufacturing processes for longer periods of time, the need for a local parts inventory may not be critical. A routine inspection and preventive maintenance program should also be developed to minimize mechanical failure in treatment plant equipment.

Perhaps the most important part of the preventive program in connection with operating procedures involves personnel training. This training must include not only waste treatment personnel, but production people throughout the plant. The hazards of accidents, the importance of notifying supervisory personnel and the importance of preventive maintenance should be included in the training. Training should include the simulation of pollution incidents and the testing of contingency plan procedures. Certainly one of the most basic parts of such a training effort should be the development of a clear-cut chain of command for responsibility and supervision of all aspects of spill control and clean-up.

A detailed analysis should be made of the possible effects of the loss of electrical power. The fate of reactive materials that might be lost during extended power failures should be investigated and facilities for maintenance and safe handling should be provided. Other external factors that should be considered include the effects of storms, floods, strikes, and the entrance of vandals on plant property.

Contingency planning should include arrangements for prompt performance of contractual services on short notice. Advance planning arrangements should be made with local contractors. Equipment suppliers should be contacted to determine the availability of rapid delivery of necessary equipment for removing pollution hazards. Local, state, interstate and federal agencies should be included in contingency planning since some of these agencies have equipment and services available for emergency use. Cooperative agreements with neighboring industrial plants should also be investigated. The petroleum industry has already taken the lead in this area.

Our program requires the submission of a formal report on Pollution Incident Prevention. The report is to consist of six parts:

1. A review of the past history of incidents or near-miss incidents,

2. A proposal of corrective action to prevent the recurrence of the past incidents,

3. A summary of the results of the review of plant operations, external factors, and contingency planning,

4. An analysis of the preceding information and a list of most probable incidents,

5. A preventive program to avoid the most probable incidents, and,

6. A schedule for implementation of the necessary corrective work, training, communication work, and contingency planning.

An effective plan to prevent pollution incidents will also specify updating of the plan at reasonable intervals.

There are some fringe benefits associated with good pollution incident prevention planning. Reduction in liability insurance rates may be available to industrial plants that have received government approval of a program to minimize pollution incidents. There are definite public relation benefits to the plant that has received approval of its preventive program. If an accident does occur at such a plant, we in government will support the plant operator who has taken all reasonable precautions to avoid pollution incidents.

Changes were made in our Clean Streams Law in August of 1970. The following section on Potential Pollution was added to the Act:

"SECTION 402. POTENTIAL POLLUTION

(a) Whenever the board finds that any activity, not otherwise requiring a permit under this act, including but not limited to the impounding, handling, storage, transportation, processing or disposing of materials or substances, creates a danger of pollution of the waters of the Commonwealth or that regulation of the activity is necessary to avoid such pollution, the board may, by rule or regulation, require that such activity be conducted only pursuant

to a permit issued by the department or may otherwise establish the conditions under which such activity shall be conducted, or the board may issue an order to a person or municipality regulating a particular activity. Rules and regulations adopted by the board pursuant to this section shall give the persons or municipalities affected a reasonable period of time to apply for and obtain any permits required by such rules and regulations.

(b) Whenever a permit is required by rules and regulations issued pursuant to this section, it shall be unlawful for a person or municipality to conduct the activity regulated except pursuant to a permit issued by the department. Conducting such activity without a permit, or contrary to the terms or conditions of a permit or conducting an activity contrary to the rules and regulations of the board or conducting an activity contrary to an order issued by the department, is hereby declared to be a nuisance."

There is no longer any doubt that we now have ample legal authority to control the troublesome problems of potential pollution. Implementation of this section was begun in November 1970 with the adoption of rules and regulations to require:

1. Notification of the Department and downstream water users when an accident or spill occurs.

2. All necessary steps to minimize damage to downstream water users including the removal of the polluting substance from the ground and from any affected waters.

3. Permits for the maintenance and operation of wastewater impoundments even though a discharge to ground or surface waters is not intended.

The regulations on impoundments require structural stability, impermeability of side walls and bottom, the maintenance of at least two feet of freeboard at all times, and protection against the actions of third parties. Permits are required for all impoundments in excess of 250,000 gallons. As a matter of policy, permits will not be issued for the continued operation of impoundments located on flood plains, or for the storage of toxic wastes or petroleum or petroleum products in earthen impoundments, or for the storage of biodegradable wastes in a location so near to a stream that it would be difficult to intercept or trap any loss of wastes to prevent its reaching the stream. For purposes of regulation, an impoundment is

defined as any depression, excavation or facility situated in or on the ground, whether natural or artificial and whether lined or unlined. The regulations permit the Department to require permits for any impoundment when it is determined that a permit is necessary for effective regulation to insure that pollution will not result.

The next area of potential pollution that we plan to work on is the transportation and bulk storage of petroleum and petroleum products. There is a great need for preventive work in this area since nearly 40% of the pollution complaints we receive involve oil spills of one kind or another.

Our pollution incident prevention program has been in effect for a little over a year now. All applicants for new permits for the treatment of industrial wastes must include preventive planning as a part of their application. Over 400 old permittees have been ordered to prepare pollution incident prevention plans and most have done so. The regulations on impoundments are being implemented. The regulations enabling us to order the removal from the ground of polluting substances has been used successfully on numerous occasions to prevent future problems. But we are continuing to experience spills and accidents.

Fifty-six incidents occurred during 1970 compared with 71 per year for the previous 7 years, for a 21% reduction. Of more significance is the change in sources of accidents. Industrial plants were involved in only 14% of the incidents during 1970 while they were involved in 31% of the incidents in prior years. We think the program is beginning to work.

I would like to use the remaining time that is available to me to discuss a pollution incident prevention project that the Department became involved in during the past year. As I mentioned earlier, prior to August of 1970 we had little or no legal authority to control potential pollution situations. A chemical plant specializing in the reclamation of copper from spent plating and etching solutions was constructed in Bucks County, Pennsylvania in 1964. The reclamation of the copper produced considerable volumes of acid wastes containing large amounts of iron, chromium, ammonia, copper, sulfates and chlorides.

To avoid our control, the plant operator did not apply for a permit for the treatment of the wastes, but attempted to store the wastes in earthen impoundments excavated into fractured bedrock. At one point he attempted to spray irrigate the chemical wastes and proceeded to kill most of the vegetation on the site. Ground water was contaminated and numerous spills of wastes reached the streams in the area. Five years of law-suits and court orders failed to resolve the problem.

In December of 1970 the courts recognized an impending disaster and ordered the operations of the plant suspended. The order also required the land owner to abate the pollution problems. Four months after the plant was closed the impoundments containing several million gallons of toxic wastes were brimful and in danger of failure. The court in March 1970 ordered the land owner to shore up the lagoons and an additional freeboard of three feet was provided. We continued to fight the legal battle for removal of the wastes throughout the summer and fall of 1970. Enactment of the August 1970 amendments to our law enabled our Board to issue an order authorizing the Department to take whatever steps were necessary to abate the potential pollution threat. An emergency appropriation was made to finance the project.

We invited a number of waste disposal and consulting firms to bid on the project. The bid specification permitted two options -- treat and discharge the wastes, or remove them from the site. A number of earthen ponds, the largest containing 2.5 million gallons of waste, several thousand rusting drums containing various spent plating and etching solutions, and dozens of vats and tanks containing a variety of chemicals were involved. We estimated the total volume at 3.5 million gallons.

The streams draining the area are very small. Bids for treatment and discharge of the wastes would require six months for completion since treatment equipment would be erected and the treated wastes could be discharged only at a limited rate to avoid further contamination of the receiving stream.

Before winter weather set in, the walls of the 2.5 million gallon impoundment began to slump. We were saved from a massive failure by freezing weather, but we knew that the spring thaw would bring disaster. Our only remaining option was to contract for removal of the wastes for offsite disposal before the spring thaw. At a cost in excess of $400,000 we contracted with an ocean disposal firm for neutralization of the acid wastes, precipitation of the heavy metals, ocean disposal of the supernatant, and burial of the sludges on site. The contractor selected was equipped to act quickly and was required to remove the liquids in the impoundments by the end of February 1971.

The immediate danger was removed before the spring weather arrived. Completion of the sludge conditioning and burial was delayed by wet weather, but the project was concluded in mid-April.

The project was complicated by out-of-state ownership of the plant and the land and by several lawsuits involving the ocean disposal aspects. We do not favor ocean disposal; in fact, we discourage it whenever possible. We had a very difficult time convincing the public that we were requiring treatment of the wastes prior to ocean disposal and that minimal dilution would be required to meet acceptable concentrations to protect marine life.

Time does not permit me to discuss the details of the project and the numerous problems that developed. I cite the project only as an example of a potential pollution incident that was abated. We proved that it can be done, and we now expect others in Pennsylvania who have caused similar threats to water use to proceed quickly to prevent pollution incidents.

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"WATER ENVIRONMENTAL STUDIES AND WATER QUALITY CONTROL AT ONTARIO HYDRO"

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INTRODUCTION

Since World War II, Ontario's electrical power requirements have increased at an average rate of 7.3% per year, which means the system capacity must double about every decade. In the last ten years, the growth has even exceeded this rate, being some 7.8% per year, and there is no indication of a reduction in the foreseeable future. As there are now only minor hydro-electric sites remaining, relative to the demand, there is no alternative but to carry out a continuing program of major fossil-fired and nuclear generating station construction. As the actual load increase each year is very large, it is necessary from both the economic and practicability standpoint that the new station be very large and have large generating units. Such stations require very considerable volumes of water for cooling purposes and for this reason the stations are all located on the Great Lakes or connecting channels. Ontario is indeed fortunate in having a shoreline on four of the five Great Lakes, and these large bodies of cold water are a great natural resource, which, when utilized for this purpose, provide substantial benefits to the power users of Ontario. Any other form of cooling is both less efficient and considerably more costly.

It is necessary to know, however, whether using the Great Lakes water for cooling purposes adversely affects the water environment and, if so, to what degree. Most investigations to date of such effects have taken place in warmer climates and in very much smaller bodies of water, mostly rivers and small lakes. There has been no evidence of adverse effects in the Great Lakes from waste heat emissions to date, however, it is only recently that very large stations have been operating on the lakes.

Ontario Hydro is carrying out very comprehensive studies in connection with the new stations to gather water environmental information before and after its plants are built, and at the Nanticoke site on Lake Erie these studies are being made in co-operation with the Ontario Water Resources Commission and the Ontario Department of Lands and Forests. Such studies include the gathering of physical data before the plants come into service, and similar measurements after operation begins, from which physical and mathematical analyses are made to permit predictions of the actions at other sites. These investigations are described in Part A of this paper. Similarly, programs are being instituted to obtain biological information in the station area to determine the effect, if any, of the heated effluent on living organisms. These studies are described in Part B of this paper.

As noted above, the new generating stations are very large, posing new problems in such areas as: controlling heat discharges; handling suspended and dissolved solids; and in the neutralizing of process water effluents. In Part C of this paper, the methods and systems developed to handle these problems are described.

PART A

WATER ENVIRONMENTAL STUDIES

PHYSICAL FACTORS

1. PURPOSE AND SCOPE OF STUDIES

Information of a physical nature from the water environment at the site of a major fossil-fired or nuclear generating station is necessary for two main reasons; (1) to assist in the design of the station, and; (2) to provide background environmental information both before and after the station comes into operation, to enable its effect, if any, to be assessed. For the design of the plant, information is required as to water temperatures throughout the year, water currents and their relationships to winds, the nature and action of ice, the location and action of aquatic weeds, and a knowledge of underwater topography. Such data is necessary for the efficient design and location of the intake and outfall structures. For environmental background information, the same physical information noted above is also required, but on a more widespread and comprehensive basis. For example, temperatures are necessary not only in the general area of intake and outfall, but also along adjacent shorelines, and at various depths and distances out from the shoreline. Ideally for both of the above purposes, the gathering of information begins several years before the design of the station, in order to have a sufficient history of data for design purposes. For environmental purposes, the gathering of data continues during the construction of the plant and after the station comes into service.

After operation begins, a special program is carried out to observe and map the thermal plume. This involves methodical offshore temperature measurements at multiple depths to determine the extent of the plume, its thickness, and to measure temperature variations within the plume. These measurements are accompanied also by a variety of meteorological measurements in an

effort to enable the plume action to be related with relevant parameters and thus develop the basis for predictive mathematical models. As the path of the plume is generally variable, and depends on many factors, a large number of measurements are necessary to determine its area of possible effect. Determination of the area over which it extends is of importance in connection with the biological observation program.

2. DATA GATHERING PROGRAM

(1) Extent of Programs

In Fig. 1, a map of the lower Great Lakes, are shown the areas in which water environmental data gathering programs by Ontario Hydro are now in effect, and in Table AI below are summarized the observations made at the various sites. At the Nanticoke site on Lake Erie, the program began in 1967 by Ontario Hydro, and in 1968 became a co-operative effort with the Ontario Water Resources Commission and the Department of Lands and Forests.

(2) Instrumentation Used

In general, water temperatures have been measured by indicating and recording electric thermometers with thermistor sensors, by recording thermometers with bi-metal sensors, and to a limited degree by reversing deep-sea thermometers and a bathythermograph. Water current direction and velocity are recorded by in-situ current meters which in addition also record water temperature and are also measured by drogues whose path is determined by transits from shore-based stations. Wind is recorded using two different types of anemometers, and MSC 3-cup and Gill microvane, both fitted with stripchart recorders.

(3) Results of Programs

The data collected in the program is reported on an annual basis and is too numerous for inclusion in this paper. However, certain observations are thought to be of interest and are reported herein as examples of the nature of the information obtained.

In Fig. 2 is shown a plot of continuously measured water temperatures recorded in Lake Huron offshore from the Bruce station in 40 feet of water during the summer of 1969. It will be noted that throughout the summer, the temperature at 40-foot depth changed by as much as 20°F, sometimes in a matter of hours, and remained at one extreme or the other for periods of several days. Correlation with wind observations indicated in general that the periods of elevated temperature at 40-foot depth coincided with periods of winds from the south quadrant, while periods of cold temperature occurred when winds were from the north quadrant. The existence of this type of temperature change through 40 feet of depth all summer from natural causes is of interest when considering the much more local effect of thermal plumes.

In Fig. 3 is plotted the daily mean water temperature of Lake Erie at Nanticoke during 1967 and 1968. Fig. 4 shows the daily mean water temperature in Lake Ontario at Pickering at 25-foot depth. Inspecting these figures, it is interesting to note the differences in the lakes. At Pickering on Lake Ontario, wide variation occurs in the temperature during the summer, similar to Lake Huron at the Douglas Point site. On Lake Erie, however, once the summer period is reached, very little variation takes place in the water temperature.

Many interesting observations were made in the course of the ice program, and in Fig. 5 are shown some views of ice accumulation on Lake Huron during the past winter. These ice cliffs, reminiscent of the Arctic, are caused by ice from Lake Huron being driven toward the eastern shore by successive storms, where it grounds in shallow water. These accumulations together with spray from the waves, build cliffs up to 45 feet above the water.

Observations of weed growth are usually made from the air and in Fig. 6 is shown a weed bed off Lake Erie near Nanticoke. A typical accumulation of dead weeds on the shore following their senescence and subsequent uprooting by a storm, near Pickering on Lake Ontario, is also shown.

3. THERMAL PLUME OBSERVATIONS

(1) General Considerations

The discharge of thermal plumes from large thermal stations into large lakes is a relatively new phenomenon on which very little authoritative information is available. The "thermal plume" is the path in the lake taken by the stream of cooling water which is discharged from the plant and is elevated in temperature, as compared to the lake water, after passing through the condenser. Most information pertains to emissions into much smaller lakes or rivers where a quite different action results and mixing is often the preoccupation. The Ontario Hydro studies were undertaken to obtain factual information on the movement and extent of such plumes. This information would enable predictions to be made of the extent and action of plumes from other stations and which could be used in the development of mathematical and physical models.

(2) Extent of Thermal Plume Investigations

Plume observations are necessarily limited to operating plants, and the Lakeview Generating Station is the first major plant at which measurements could be made. Such measurements commenced at that station in 1969, and since then have been made on forty-five separate occasions. The thermal plume action is affected by many variables among which are: inlet water temperature, air humidity, air temperature, wind speed and direction, radiation, season of the year, and load on the station. It is unavoidable, therefore, that many observations are required to include the effect of all these variables.

In 1970, the Lambton Station came into operation, and programs were initiated to measure the thermal plume from this station into the St. Clair River. There is quite a difference in the action of a thermal plume in a lake as compared to a river, and these results are included also.

(3) Method Used in Obtaining Plume Observations

In general, the method used in detecting and measuring the plume, is to lay out first a rectangular grid covering the lake area in question. When the observation is to be made, a boat traverses this grid as rapidly as possible, recording the water temperatures at one foot and at five-foot depths. When the plume location is detected, temperatures are taken at multiple depths from one foot depth to the bed, at selected grid intersections. In this way the temperature distribution within the plume is determined. At the same time, intake and outfall temperatures are being taken; meteorological measurements are also being made of air temperatures, humidity, wind direction and speed, solar radiation and net radiation. Some experimentation has been made with infrared thermometers and imagery but as yet these methods have not proven to be satisfactory in providing the information required.

(4) Results of Thermal Plume Observations

For each of the forty-five separate occasions when observations were made at Lakeview, the measurements were reduced and plotted, and isotherms drawn within the plume for one foot and five-foot depths. Because of the very large number of observations made, all of the data cannot be given in this paper. In Fig. 7 and Fig. 8 however, the plumes and resulting isotherms are shown for four selected different conditions. In each figure is given the data relevant to that particular occasion. Similar plots were made for each set of data obtained, and in Table AII is given the significant information obtained from the plots shown in Fig. 7 and Fig. 8, and the others not presented in this paper. In general it has been found that the plume does not exceed about ten feet in depth, and floats in the colder lake water. Also the plume extends a maximum of about two miles from the outfall, where all measurable temperature effects disappear.

In Fig. 9 is shown plotted the results of the Lambton thermal plume observations and it is interesting to note the difference in plumes in lakes and rivers.

4. PRELIMINARY STATISTICAL ANALYSIS OF THERMAL PLUME

(1) General Remarks

As may be deduced from an inspection of the preceding figures and Table AII, the action of the thermal plume is most complex and is affected by many variables. The physical laws governing this phenomenon are under study and it is hoped that a mathematical model incorporating the various factors affecting the plume can be produced, which will enable dependable prediction to be made of the action. However, to best utilize the available information and to enable reasonably good prediction to be made at other proposed sites, a statistical study has been made of the Lakeview data, and although many of the relevant parameters are not represented it is believed that the general dimensions of the plume can be predicted and the area of effect established with reasonable accuracy. It must be emphasized, however, that the analysis is preliminary only and will in due course be displaced by a more rigorous analysis.

(2) Method of Preliminary Statistical Analysis

As a preliminary analysis, it is noted that for a given temperature drop between outfall and ambient lake, the area of the plume and the distance it extended from the outlet to the end of the plume, were reasonably consistent in three different time periods: summer; winter; spring and fall. The observation in these three periods was segregated, and plots made of the area of the plume in terms of the temperature difference between outlet and any given isotherm for each season. These plots are shown in Fig. 10. Also, between the outlet and successive isotherms, in Fig. 11 is plotted the area of the plume relative to the term "area divided by centre-line distance" or mean width, which shows a relatively consistent pattern in all seasons. The data, reduced from the isotherm plots, from which Figures 10 and 11 were drawn, are given in Table A III. It was observed in addition that the general form of the plume was similar to the mathematical shape known as the "lemniscate" and Fig. 12 gives the mathematical description of the shape. It was noted

also that the path of the plume was deflected by wind induced current prevailing at the time of the test, and it was found possible to approximate this deflection by a mathematical relationship also indicated in Fig. 12.

For a given season, temperature difference and wind situation, it was possible by utilizing Fig. 10 and Fig. 11 and Fig. 12 to reconstruct a plume which on the average agreed with the observations. In Fig. 13 and Fig. 14 are shown such reconstructed plumes as compared to observed plumes for the same conditions at Lakeview. In reconstructing the plume for July 16, 1969, it was found that the land configuration rather than the wind direction, which was directly into the outfall, governed the direction of the plume. For this particular condition, therefore, the plume centreline was drawn manually rather than by mathematical formulae.

(3) Utilization of Prediction Process for other Installations

It is considered that the prediction process described above yields reasonably satisfactory results for the Lakeview Plant conditions. For other plants of similar capacity and cooling water flow, the analysis should also be reasonably close. However, if the analysis is to be applied to plants where the capacity and cooling water flow are dissimilar to Lakeview, it would be necessary to know whether the plume area would vary directly or in some other relationship to the cooling water flow. Such information will be obtained in due course when other stations come into service, but at present is not available. An assumption in this regard would be necessary if the method is to be used now for dissimilar plants. If a direct relationship between plume area and rate of cooling water flow were to be assumed, it would probably be on the conservative side for larger plants.

Table AI

WATER ENVIRONMENTAL MEASUREMENTS (PHYSICAL) BY ONTARIO HYDRO

Site	Physical Factors				
	Water Temperature	Water Currents	Aquatic Weed Beds	Ice	Wind
Lake Ontario					
Lennox	1969-71	1969	1968-71	1969-71	1969-71
Wesleyville	1968-71	1968-71	1968-71	1969-71	1970-71
Pickering	1970-71	1970-71	1968-71	1969-71	-
Lakeview	1969-71	1970-71		1970-71	
Lake Erie					
Nanticoke	1967-68 1970-71	1967-68	1967-70	1967-71	1967-71
Lake Huron					
Bruce-Douglas Point	1969-71	1969-71	1969-71	1969-71	-
St. Clair River					
Lambton	1970-71	1970-71		1970-71	1965-71
Niagara River				1967-71	

TABLE A II

LAKE ONTARIO

LAKEVIEW GENERATING STATION

WATER TEMPERATURE SURVEYS

Date	Time	Plant Data: No. of Units	Plant Data: Output Mwe	Cooling Water: CCW Flow Cfs	Temperature - °F: In	Temperature - °F: Out	Temperature - °F: Raise	Wind Dir. & Vel.	Air Temp. °F	Rel. Hum. %	Net Radiation Langleys/hr.
1969											
May 22	1000-1300	4	1175	1400	46.0	62.0	16.0	ENE 9-15	50		
23	1000-1300	4	1170	1400	45.5	61.0	15.5	ESE 4—6	59		
June 19	1000-1330	4/5	1215	1830	47.0	58.6	11.6	SW 12	60		
July 15	1500-1700	4	1170	1730	60.7	74.5	13.8	SSW 8-10	82		
July 16	1340-1600	4/5	1275	1730	62.2	76.1	13.9	SSW 13	83		
17	1240-1500	4	1180	1620	61.7	74.5	12.8	SSW 10	83		
22	1245-1510	5	1330	1750	69.3	84.7	15.4	ESE 9	75		
23	1215-1400	5	1200	1750	71.7	84.0	13.3	E 10	75		
24	1200-1440	5	1460	1750	71.5	86.6	15.1	SSE 7	76		
Sept 9	1300-1500	5	1430	1970	59.0	71.9	12.9	NW 14	66		
10	1330-1500	5	1430	1750	53.0	67.4	14.4	WNW 10	61		
11	1300-1445	4/5	1330	1750	55.0	68.5	13.5	WSW 3—10	63		
30	1345-1600	5	1492	1830	58.0	71.0	13.0	NW 16	66		
Oct. 1	1345-1600	5	1340	1830	58.4	72.5	14.1	E 13	60		
2	1315-1500	5	1434	1980	60.0	74.0	14.0	E 10	61		
21	1430-1700	5	1460	1740	44.0	61.7	17.7	NW 10-24	48		
22	1300-1535	5	1375	1760	43.0	58.0	15.0	WNW 15	31		
23	1215-1515	4	1190	1720	42.0	55.6	13.6	NW 8	33		
Nov. 12	1300-1600	5	1483	2130	47.4	60.7	13.3	WNW 20	45/50		
13	1330-1600	4/5	1216	2140	48.0	59.2	11.2	W 10-15	40/45		
25	1340-1515	6	1635	2040	42.0	57.0	15.0	SSW 13	45		
26	1330-1600	5	1490	2030	41.8	55.8	14.0	NW 15-20	40		
1970											
Jan. 28	0945-1215	8	2240	2520	38.8	55.8	17.0	SE 14	36		
Feb. 3	1420-1720	7	1970	2190	34.0	51.7	17.7	NNW 14	8		
4	1320-1605	7	1940	2150	33.3	51.4	18.1	SW 12	13		
20	1340-1610	7	1940	2205	43.0	61.0	18.0	W 21	22		
May 20	1300-1650	6	1820	1920	45.0	63.0	18.0	SW 4	52		
June 11	0830-1100	5	1460	1850	48.0	62.0	14.0	W 9	71	67	56.1
11	1230-1510	5	1460	1740	48.0	65.0	17.0	NW 15	84	39	64.1
July 29	0840-1040	4	930	1900	60.0	70.0	10.0	E 2	71	88	51.7
29	1315-1500	4	1210	1890	58.0	70.0	12.0	E 2-5	75	86	59
Sept 1	0920-1110	5	1320	2270	51.0	63.0	12.0	N 5	67	48	56
1	1300-1455	5	1320	2270	56.0	65.0	9.0	SSE 9	65	69	45.9
2	0830-1050	6	1630	2440	54.0	68.0	14.0	SSE 1—6	60	66	33.8
2	1225-1425	6	1430	2380	55.0	67.0	12.0	ESE 7	65	69	44
Oct. 20	0910-1110	6	1740	2080	54.0	70.0	16.0	E 8	53	71	20
20	1245-1530	6	1760	1980	55.0	72.0	17.0	ENE 16	54	72	14
22	0845-1045	6	1670	1970	56.0	72.0	16.0	ENE 11	55	92	11
22	1150-1450	5	1490	1630	55.0	72.0	17.0	E 4	56	89	12

TABLE A III

DATA FROM ISOTHERM PLOTS

Date		Isotherm Temperature °F	Loss in Temperature °F	Accumulated Area Sq.Ft. x 10^6	Centre Line Distance, Ft. x 10^3
1969					
May	22	60	2	0.245	2.1
		58	4	0.930	4.0
		56	6	2.545	5.2
		54	8	3.755	6.3
		52	10	5.540	7.2
	23	60	1	0.065	0.6
		58	3	0.125	0.75
		56	5	0.835	2.4
June	19	56	2	2.755	3.4
		54	4	8.235	3.9
		52	6	16.730	5.9
July	15	74	0.5	5.970	3.4
		72	2.5	15.120	8.0
	16	76	2	0.370	1.3
		74	4	8.570	5.9
		72	6	21.035	9.5
	17	72	3	1.150	1.5
		70	5	6.360	3.2
	22	82	2	0.295	1.1
		80	4	1.650	1.6
	23	82	2	0.400	1.3
		80	4	1.825	2.25
	24	84	2	0.425	1.1
		82	4	1.520	2.0
		80	6	3.930	4.0
		78	8	10.110	7.0
		76	10	16.150	7.65
September	9	70	2	1.385	2.1
		68	4	4.665	3.7
	10	68	1	6.165	2.7
		66	3	15.420	5.4
	11	72	2	0.390	1.4
		70	4	1.175	2.0
		68	6	3.015	2.8
		66	8	4.885	3.5
		64	10	6.330	4.2
		62	12	9.585	5.4
	30	72	1	0.110	0.7
		70	3	0.355	1.0
		68	5	1.430	2.1
		66	7	2.470	2.6
		64	9	6.030	3.4
		62	11	12.665	5.1

Date		Isotherm Temperature °F	Loss in Temperature °F	Accumulated Area Sq.Ft. x 10^6	Centre Line Distance, Ft. x 10^3
1969					
October	1	72	1	0.225	0.9
		70	3	0.695	1.4
		68	5	1.910	2.0
	2	74	1	0.170	0.75
		72	3	0.765	2.2
		70	5	3.210	4.5
	21	60	2	0.320	1.0
		58	4	1.295	1.9
		56	6	2.085	2.3
		54	8	3.305	2.4
		52	10	4.380	2.9
		50	12	6.025	3.1
		48	14	8.790	4.9
		46	16	14.315	5.3
	22	56	2	0.765	1.7
		54	4	1.290	2.1
		52	6	2.575	2.9
		50	8	5.275	4.4
		48	10	14.450	6.5
		46	12	20.995	8.0
	23	54	2	0.250	0.9
		52	4	2.030	3.6
		50	6	4.435	4.6
		48	8	13.140	6.6
		46	10	22.005	8.0
November	12	62	4	0.150	0.9
		60	6	0.230	1.0
		58	8	0.420	1.2
		56	10	1.280	2.6
		54	12	2.745	3.0
		52	14	4.285	3.4
	13	58	2	0.595	2.0
		56	4	1.385	2.5
		54	6	2.580	3.1
		52	8	5.195	3.6
		50	10	8.810	5.2
	25	56	1	0.390	1.2
		54	3	3.815	2.2
		52	5	5.100	2.6
		50	7	6.530	3.0

T A B L E A III

DATA FROM ISOTHERM PLOTS

Date		Isotherm Temperature °F	Loss in Temperature °F	Accumulated Area Sq.Ft. x 10^6	Centre Line Distance Ft. x 10^3
1969					
November	26	56	2	0.120	0.8
		54	4	0.415	1.9
		52	6	1.140	2.4
		50	8	2.295	2.5
		48	10	5.245	2.6
		46	12	8.055	3.0
		44	14	15.21	4.1
1970					
January	28	54	2	1.875	2.5
		52	4	4.275	4.0
		50	6	6.865	5.0
		48	8	8.170	5.2
		46	10	9.795	5.3
		44	12	10.410	5.4
		42	14	14.990	5.5
		40	16	16.325	5.55
		38	18	17.340	5.6
		36	20	18.175	5.65
February	3	48	4	2.370	3.4
		46	6	5.570	5.0
		44	8	8.950	6.4
		42	10	11.540	8.2
		40	12	14.695	8.9
		38	14	16.830	9.1
	4	48	4	1.100	2.6
		46	6	3.470	3.8
		44	8	5.160	4.4
		42	10	7.565	4.9
		40	12	9.670	5.0
		38	14	13.040	5.05
		36	16	14.965	5.1
	20	60	1	0.190	1.0
		58	3	0.560	1.7
		56	5	0.890	2.2
		54	7	1.260	2.5
		52	9	2.050	3.0
		50	11	2.880	3.6
		48	13	4.255	4.3
		46	15	4.620	4.5

Date		Isotherm Temperature °F	Loss in Temperature °F	Accumulated Area Sq.Ft. x 10^6	Centre Line Distance Ft. x 10^3
1970					
May	20	60	3	1.690	2.1
		58	5	3,880	2.5
		56	7	6.920	3.7
		54	9	8.760	4.0
June	11	62	2	0.585	1.5
		60	4	4.730	4.6
		58	6	8.020	5.2
		64	1	0.225	1.1
		60	5	1.495	2.9
		58	7	3.360	4.3
July	29	68	2	0.090	0.8
		66	4	0.935	2.6
		68	2	0.710	1.8
		66	4	1.520	2.2
September	1	62	1	0.280	1.0
		64	1	0.235	1.2
		62	3	3.500	4.3
	2	66	2	1.925	4.1
		64	4	6.985	5.6
		62	6	14.000	7.8
		60	8	28.215	10.6
		66	1	2.335	6.1
		64	3	6.430	7.0
		62	5	19.295	7.6
October	20	66	4	1.215	2.8
		64	6	4.050	3.9
		62	8	7.185	5.6
		68	4	1.330	2.8
		66	6	3.580	4.6
		64	8	6.135	7.2
		62	10	9.730	8.5
		60	12	12.620	9.1
		58	14	17.030	9.6
	22	68	4	0.475	1.4
		66	6	1.175	1.6
		64	8	2.630	2.9
		62	10	5.230	5.3
		68	4	1.120	2.1
		66	6	2.990	4.2
		64	8	4.745	5.5

P A R T B

BIOLOGICAL STUDIES

1. EFFECTS OF THERMAL DISCHARGES

Members of an aquatic ecosystem may be affected directly by an increase in water temperature or indirectly by the effect of temperature on some other property of the water. The most important indirect effects of temperature which have biological significance are density, the capacity to hold gases and rates of chemical or biochemical reaction. A decrease in density brought about by increased temperature causes stratification of the thermal discharge which will define its three-dimensional limits and therefore the extent and duration of its effects. The use of density differences for dispersing warmed water over the surface of a receiving body will tend to minimize temperature influences on bottom-living organisms but will prolong the exposure time at elevated temperatures for those organisms which are entrained in the thermal discharge. The influence of temperature on the capacity of water to hold gases is of importance with respect to the amounts of dissolved oxygen required for the support of aquatic organisms. Transient temperature rises, as in a thermal discharge, may not cause oxygen loss as has been shown by actual experimentation at a number of generating stations, including one station of the Ontario Hydro. Dissolved oxygen levels may become limiting when increased biochemical activity, due to a temperature increase, place an increased oxygen demand on the water. Other secondary biological effects of heated discharges may be attributed to synergistic reactions with toxicants and other pollutants in the water.

These numerous indirect effects are in addition to the direct effects of elevated temperatures on aquatic organisms such as feeding habits, growth, metabolism, reproduction, development and locomotion. The study of these effects has produced a vast literature and a large number of conferences on the subject. In spite of the intensive research effort in this field there is still little consensus on the actual significance of the biological changes which occur in natural waters due to elevated temperatures.

Some of the reasons for this are clear. The complexity and diversity of aquatic systems are such that they do not permit the development of general rules by which effects can be defined. There is no fixed temperature range for a given aquatic ecosystem beyond which the system is irreversibly damaged. Seasonal and other climatological changes strongly influence the biological response of the ecosystem which have to be separated from man-made thermal influences. Finally, laboratory results are often difficult to apply to the study of an on-site situation. For these reasons there is some difficulty in defining those changes in the aquatic ecosystem brought about by heat which can lead to the use of the term "thermal pollution". As a working guideline, thermal pollution may be considered to exist when changes or shifts in the species distribution and populations at a given trophic level are of such magnitude that the existing food web is disrupted and unbalanced. Using this concept of thermal pollution and recognizing the previously mentioned difficulties in assessing the problem, the Ontario Hydro believes that the most reliable way of defining temperature effects is by on-site studies of the natural environment. To this end, studies are now being carried out and are planned at each of the thermal generating station sites.

When plans for building the Nanticoke Generating Station on Lake Erie were announced, the concern over lake environmental effects led to the formation of a Nanticoke Environmental Committee in 1968, the original members of which were the Ontario Water Resources Commission, the Department of Lands and Forests and Ontario Hydro. This committee, under the chairmanship of a member of the OWRC, developed a co-operative program of studies to be carried out by each of those member groups having the required technical skills. In 1969, the Steel Company of Canada, and in 1970, Texaco, joined the committee after announcing their respective plans for developments in the area. The environmental program was modified slightly to accommodate these companies' specific interests and concerns. The biological program consists of studies on fish populations, spawning and movements, measurements of phytoplankton, zooplankton and bottom-living organisms, and observations on the distribution and life cycle of filamentous algae. These various studies are planned to

extend beyond the period when the generating station and other industries become operational. The pre-operational phase should allow the development of a simplified model ecosystem in which changes in the most important member organisms of each trophic level can be studied in relation to changes at other levels of the ecosystem. A more detailed description of the environmental studies at Nanticoke was published in April 1971.(1.)

At the Lambton Generating Station, located on the St. Clair River, there was some concern that the thermal discharge would add to the adverse effects of the existing high pollution load from other industries. In 1970, after the first two units of the station became operational, the Ontario Hydro started a program to determine the downstream effects of the thermal discharge. At a river location it is believed that the most reliable indication of any effects can be found by an examination of the relatively immobile and long-lived organisms inhabiting the river bottom. The main part of this program, therefore, is to measure the changes in population and density of bottom-living organisms at increasing distances from the discharge point over four seasons of the year for at least two years. Similar measurements above the discharge point are being used as controls. Existing knowledge of the tolerance of each species to various pollutants and temperature regimes will allow an estimate to be made of any effect due to the thermal discharge and the distance downstream of this effect. Such measurements have been of value for monitoring pollution levels in the St. Clair River in studies supported by the Lambton Industrial Society in 1963 and 1968. The OWRC has used similar methods for surveying the river. Other concerns at the Lambton Station include the effect of the thermal discharge on fish and weeds. Populations of fish in the upstream and downstream stretches of the river are being measured and rates of growth and general condition recorded. Aquatic weed growth is of concern because there are three parks along the shoreline. Weed beds at near-shore and on-shore locations have been surveyed and the species composition determined during the period when the station was coming up to full capacity. During the next two years any changes in species composition, distribution and density will be determined.

At Pickering Nuclear Generating Station a pre-operational program of biological studies was started in September 1970. The composition and distribution of bottom-living organisms was again chosen to be the major part of the program for measuring the effects of the thermal discharge. Seasonal samples are being taken from fixed stations at increasing distances from the point of the discharge into the lake. Two control stations are located outside the area expected to be influenced by the thermal discharge. In 1971 qualitative plankton determinations are to be made. In addition, fish studies will determine the most abundant and important species, distribution and physical condition. These studies are to be continued during the commissioning of the station and for a period after full capacity has been reached. Supplementary information on water quality changes is being obtained at this site in order to attempt to separate any future biological changes into those caused by lowered water quality and those due to thermal influences.

At Lakeview Generating Station some studies were started in 1968 when six of the current eight units were in service. Measurements of dissolved oxygen were made at each season of the year on both intake and discharge cooling water in order to measure the changes in levels due to heating in the condensers. It was found that no significant loss of dissolved oxygen occurred either in the condensers or during the time when the cooling water was discharged into the lake. Even when the intake water was close to saturation the elevated temperature did not drive off any oxygen. The heated water remained in a super-saturated condition and was equilibrated towards lake temperature with no oxygen loss. The effect of increased water temperatures on the growth rates of filamentous algae was studied during a twelve month period in 1968-69. Using artificial concrete substrates in the intake and discharge canals it was found that the dominant filamentous form, Cladophora, tended to start its period of rapid growth approximately five weeks earlier in the discharge canal where the water was 12^{o}-$16^{o}F$ warmer than in the intake canal. However, as active growth of Cladophora occurs in the temperature range 55^{o}-$65^{o}F$, these temperatures were exceeded in mid-June in the discharge canal and the weeds started to die approximately four weeks

earlier than in the cooler water of the intake. Overall yearly growth on the substrates was similar under each temperature regime. Temperatures in the discharge canal were within the range favourable for optimum growth during early spring and part of the winter but as only little growth actually occurred it was concluded that day length and light intensity were possibly limiting growth during these periods. Analysis of epiphytic algae on the artificial substrates indicated that the number of genera was not reduced in the heated discharge water, and although there was a slight shift to green algae forms in the summer months at the expense of diatoms, blue-green algae remained of little significance even at maximum discharge temperatures of 85°F. Existing biological studies at Lakeview include further measurements of filamentous algae growth, a comparison of the distribution and populations of bottom fauna in the cooling water intake and discharge areas, and measurements of entrainment effects on phytoplankton.

At the Lakeview, Hearn and Douglas Point Generating Stations, the Ontario Hydro is supporting research at the University of Toronto on the effects of the thermal discharges on fish movements and populations. Results from one year's surveys suggest that no large populations of fish are being maintained in the thermal discharge area, possibly because temperatures tend to fluctuate and the area of the thermal discharge varies in size and location due to wind and turbulence effects. At most times of the year more fish are being caught in the warmer discharge area but at peak summer temperatures the fish tend to migrate to the cooler water. This research is being continued throughout 1971 at each of the three stations.

2. RADIOACTIVITY

The Atomic Energy Control Board in Canada sets permissible release limits for each station. These are conservatively based on the recommendations of the International Commission on Radiological Protection, and have taken into account such factors as biological concentration of radioactivity in fish. Several years of operating experience at NPD G.S. and Douglas Point G.S. have consistently shown that radioactivity releases into the liquid effluent stream are less than 5% of the permissible limits.

Environmental monitoring is independently carried out by Ontario Hydro and by external agencies (The Department of National Health and Welfare and the Ontario Department of Health). The effluent stream is routinely monitored for radioactivity. Analyses of local drinking water supplies and fish have consistently shown no detectable radioactivity levels that may be attributed to station releases. At Pickering G.S., more extensive monitoring will be carried out, to coincide with thermal effects studies planned for that site, to include a somewhat wider range of aquatic biota.

3. RELEASES OF OTHER WASTES

Emissions other than heat and radioactivity which may have a biological effect are derived from coal-pile drainage, ash disposal areas, laundry effluents, the boiler water treatment plant, boiler blow-downs, oils, greases and chlorine. These various discharges are controlled to meet existing water quality criteria. A survey is now completed for each operating station to clearly define the sources of emissions and amounts so that more efficient control of pollution can be exercised.

4. FISH REPULSION

A problem which is of both operational and environmental concern is the intake of fish in the condenser cooling water. Investigations are now being made of improved means of screening fish from water intakes. Ontario Hydro is supporting research on fish repulsion using sound. This study, which is to be carried out during 1971 by a staff member of the Royal Military College, will be concerned with finding if certain frequencies and intensities of sound can be used to produce an avoidance response in fish. Such a method, if found effective, would be of value at both shoreline and submerged water intakes.

5. BENEFICIAL USES OF THERMAL DISCHARGES

Work carried out in this field is being reviewed by Ontario Hydro in light of the specific situations arising from our climate and geographical position. Potentially interesting uses to which thermal discharge heat may be put include aquaculture, soil heating, irrigation, de-icing, sewage treatment and recreation. The use should ideally meet the following conditions:

(i) Variability in plant output must not affect the process efficiency.

(ii) Complete plant shut down for short periods could be tolerated.

(iii) Occasional use of chlorine should not be harmful.

(iv) Existing chemical and physical qualities of the water are not impaired.

(v) Water should be returned to the same water body to avoid influencing ground water levels.

(vi) Heat should be of most use in the summer when discharge temperatures are of more concern to lake ecology.

(vii) Heat should be used for enhancement of metabolic processes rather than direct discharge to atmosphere.

(viii) Any adverse ecological effects are less than by direct discharge to the water body.

(ix) Ground waters should not be warmed.

Based on these criteria the more feasible possibilities in these latitudes appear to be in agriculture where enhancement of growth rates and extension of growing season would be of value.

References:

1. "A Status Report on Environmental Studies in the Nanticoke Area", issued by Ontario Hydro on behalf of the members of the Nanticoke Environmental Committee and the Air Management Branch, April 1971.

PART C

METHODS AND SYSTEMS FOR EFFLUENT WATER QUALITY CONTROL

Scope

The operation of thermal and nuclear generating stations leads to the production of effluents which may require treatment prior to disposal in order to control pollution of the receiving waters. The sources of effluents are both internal and external to the stations.

In-plant effluents originate from ash disposal systems of the coal-fired generating stations and the water treatment plant. They are generally collected in settling tanks with provisions for solids cleanout or disposed of in lagoons sized to hold the deposited solids for the life of the plant. The overflow from the settling tanks and lagoons is drained to the receiving waters or recycled as described in this section.

The source of effluents external to the plant presently arises from the acidic drainage from the coal piles in the yard of coal-fired stations. Other sources will arise in future from yard drainage of areas surrounding oil storage tank farms or oil pumping systems.

In addition to the above effluents which affect the quality of the receiving waters, the rise in temperature of water used for condenser cooling, when discharged into the receiving waters may cause thermal effects.

1. SUSPENDED AND DISSOLVED SOLIDS CONTROL

(1) Boiler Ash Effluents

A number of Ontario Hydro's generating stations are fuelled by coal which is pulverized and burned in suspension in the boiler furnace. The coal has an ash content varying between 10% and 14%, of which 80% to 85% is reduced to particle sizes between 10 and 75 microns at the completion of the combustion process. This ash is referred to as flyash and is carried by the flue gas through the boiler passes to precipitators, which remove up to 99.5% of the flyash. The flyash is

deposited in hoppers which form part of the precipitator equipment and it must be removed at regular intervals.

The remaining 15% to 20% of the boiler ash is deposited on the boiler waterwall tubes forming a slag which eventually breaks loose and is deposited in the boiler furnace hopper. This ash is referred to as boiler bottom ash.

In addition, a relatively small amount of flyash is deposited on the heating surfaces of the boiler air preheaters which transfer heat from the flue gases to the combustion air thereby raising the efficiency of the generating unit.

To maintain the efficiency of the air preheaters, they are washed at regular intervals and the effluent is referred to as air preheater wash water.

A typical 2000 Mw coal-fired generating station when operating at full load will burn 16,000 tons of coal per day, necessitating the handling of up to 2200 tons of ash per day.

At Lakeview the flyash is conveyed from precipitator hoppers to ash silos by means of an air transport system and then is removed by truck to nearby disposal areas. The bottom ash is removed by slurry transport using high pressure water eductors at the boiler hopper discharge. The slurry is conducted to elevated hydrobins which may be visualized as conical thickeners with discharge hoppers at the bottom for disposal truck loading. Because there is one hydrobin and common ash piping for each two boilers, each two boilers has a consecutive bottom ash removal cycle.

At present the four hydrobins drain to an existing small two-compartment settling tank which overflows into Lake Ontario. This tank proved to be undersized for the quantity of water and suspended solids content which is encountered in the hydrobin overflow due in some part to the high ash content of coal now being used.

Municipal restrictions limit the trucking of wet ash during the daytime and since the boilers when operating at full load must have ash removed once per shift, bottom ash removal can take place only in the morning and late afternoon. Because half the boilers are on ash sluicing at these times, the transport water overflowing from the hydrobins fluctuates from 0 at night to a peak of 8000 gpm for periods of 2 to 3

hours daily. Consequently, any system installed for suspended solidsremoval had to be designed to handle these variations. Total maximum daily flow to be handled has been estimated at 2,500,000 gallons. Total solids to be removed by the settling tank per day is estimated at 4 to 5 tons if the discharge water quality of 15 ppm is to be obtained.

Several methods of reducing the suspended solids concentration of the hydrobin drains were investigated. From these studies it became apparent that a two-stage treatment was required - a primary settling stage and a secondary polishing stage. Various types of clarifier thickeners with vacuum filtering equipment were investigated for both stages. Cost studies indicated that a two-compartment settling tank, to be cleaned out with mobile equipment, would be the most economical for the first stage.

For the second stage it was estimated that multi-media filters would be the most economical to install and operate. It was therefore decided that this type of filter would be tested in a pilot plant prior to installing the equipment at Lakeview G.S. The arrangement of the pilot plant is illustrated in Figure 15.

The pilot filter plant was set up at Lambton G.S. because the larger settling tank there more closely simulates the final proposed arrangement for Lakeview G.S. Water for the test plant was drawn from a spot adjacent to the overflow weir.

Backwash effluent from the top of the filter was returned to the middle of the tank, approximately 75 feet from the suction inlet. Water flow rate through the filter, filter pressure drop, and filter effluent turbidity were monitored continuously by strip chart recorders. Influent and effluent samples were collected at regular intervals and analyzed in the Station chemical laboratory for suspended solids concentration.

The only problems encountered during the test were temporary shutdowns, all of which were caused by excessive wear on the supply pump glands from the abrasive ash material. It is to be noted that these pumps were standard centrifugal pumps with no special gland protection.

During a five-week period tests were carried out on the filter at each of a number of flow rates with and without chemical additions and the effect of coagulants on suspended solids removal was examined. It was found that satisfactory solids removal could be

obtained at a mass velocity of up to 10 gpm per square foot with no chemical addition. Figure 16 gives the results of a typical run. Based on these results it was decided to install high flow rate filters in the secondary stage at Lakeview G.S.

In the system to be installed the water drained from each ash sluice hydrobin will enter a two-compartment concrete settling tank as shown in Figure 17 where a major portion of the suspended solids carried by the water will be deposited.

Each compartment is 125 feet wide x 270 feet long and 10 feet deep. The tanks have been sized to accommodate a 3 foot level surge to take care of above-mentioned flow variations, in addition to providing ash storage and settling space above the ash.

Each compartment may be fed and drained independently. When the deposited solids in either compartment have reached a sufficient depth one compartment can be isolated and the solid material removed. To assist in draining each compartment, a sludge pump will be provided which will pump the fluid into the compartment remaining in operation. The process will then be reversed to clean the remaining compartment. There is a sloping entrance to each compartment to allow a front end loader to enter and remove ash after draining.

Water from the ash settling tank will flow through the tank floating suction to the air release sump where air entrained in any suction vortex will be separated out. The arrangement is illustrated in Figure 17.

Three filter supply pumps rated at 1200 gpm will draw from the air release sump. The system will be arranged such that two pumps will be in service with the third pump acting as standby. The air release sump will be fitted with level controls such that each half of the settling tank will be maintained at a water level low enough to ensure that no overflow will occur. The turbidity of the water will be recorded at the pump suction.

The filter supply pumps will feed two high rate multi-media filter vessels. Each filter vessel will be complete with isolating valves and inlet and discharge valves. There will be a common backwash system. The backwash of each filter vessel will be arranged such that only one vessel may backwash at any one time. When one vessel is backwashing, one supply pump will stop to maintain the flow through the "in service" vessel at its design rate. Backwashing effluent will be discharged back to the inlet of the settling tank. The

backwash of each filter vessel will be started by high "head loss" signal from the filter. The arrangement of the settling tank and filter station is illustrated in Figure 17.

Two horizontal pressure filters of 8 feet diameter by 20 feet long with a filtration capacity of 8 gpm per square foot are provided and the cross section of the filter showing the different filter media is illustrated in Figure 18. The filter contains three types of filter media consisting of coal, sand and gravel, each of different particle sizes and specific gravities. The largest size, coal, is the lowest in specific gravity and the smallest size gravel, the highest in specific gravity. They are arranged in layers of coal, sand and gravel from top to bottom. As the effluent passes through the filter the inter-grain spaces become progressively smaller, straining out the suspended solids in the water gradually. This gradation greatly increases the solids holding capacity of the filter. The retention of suspended solids in the filter media progressively increases the pressure drop across the filter. When the pressure drop reaches a preset maximum the filter will be backwashed to dislodge the solids from the filter media.

Provision will be included in this system for the addition of coagulating chemicals or coagulant aids, if required, to the filter influent.

The filtered water discharge enters a clearwell with an overflow weir which drains into the lake. This clearwell also serves as a backwash pump supply source.

When the air release sump is at "low" level and the pumps "off", the effluent valve of each filter vessel will be closed to keep the vessel full of water. When the sump is at "high" level, the filter valves will be opened and the supply pump started. Effluent from the filters will be monitored on recording charts for suspended solids content before being discharged into Lake Ontario.

To handle the air preheater wash water effluent, drain tanks and high water pressure eductors are being installed at the rear of each boiler so that the wash water drains can be routed to the hydrobin drain and from there to the two-compartment concrete settling tanks where they will be treated as previously described.

The Lambton flyash is collected in a system similar to that at Lakeview. The bottom ash disposal system is also similar to that at Lakeview with the

exception that the ash from the hydrobins is transported by truck to an on-site ash retaining lagoon sized to hold all solids for the plant life period of 30 years. The drains from the hydrobins enter a two-compartment settling tank, the dimensions of each compartment being 100 feet x 200 feet x 6 feet deep. The clear water from the settling tank overflow is drained into the river.

Settling effluents have been measured in the range 60 ppm to 70 ppm. Further secondary treatment of the effluent is being held pending operating results of the system described for Lakeview.

The drainage system from the air preheaters has been modified to route the wash water directly to the ash settling tanks.

The boiler ash handling system for Nanticoke differs from that at Lakeview and Lambton in that precipitator flyash, bottom ash and air preheater wash water are discharged using high pressure water eductors and transported by slurry to an ash settling lagoon. This has eliminated the hydrobins and flyash storage silos.

The lagoon provided is in two sections; the primary lagoon of 185 acres is sized to hold all the ash settled in the 30-year plant life period and the secondary lagoon of 3 acres to further clarify the overflow before discharge into Lake Erie.

The partially clarified lagoon water when discharged into the lake would create water pollution problems from high dissolved solids content of the waste which would not meet the objectives laid down by the Ontario Water Resources Commission.

To investigate the feasibility of eliminating the discharge by recirculating as much water as possible, laboratory analyses were carried out to establish the feasibility and long-term effects of recirculating the lagoon waters for the ash transport systems. Although the studies indicated that recirculation was mechanically feasible, the long-term effects of this method of recycling on the equipment in the system and the possible operating problems due to crystallization in the system have not been established. However, in the interest of water effluent control, it was decided to provide facilities for recirculation of lagoon waters. The arrangement of this system is illustrated in Figure 19.

When Nanticoke is put into service the level of water in the lagoon will be allowed to rise to a depth of 14 feet when the total volume will be 820 million gallons. At this stage, recirculation of water will commence and the flow rate will increase to a daily peak of 24,000 gpm when all eight units in the station are in operation. Once the recirculation is established, all the high pressure service water will be supplied from this source.

It was not possible to completely eliminate the discharge from the lagoon as the wash water for the boiler hopper bottom and air preheater wash is supplied from a separate low pressure service water system and this, in addition to water treatment plant effluents, results in a net input to the lagoon.

Of the total process water required for boiler ash and water treatment effluent handling 96.5% is being recycled. The remaining 3.5% will have a ph in the range of 9 to 10 and will be discharged into the lake.

(2) Water Treatment Plant Effluents

Water treatment plants are installed in all Ontario Hydro's thermal generating stations to provide make-up water of a quality and quantity specified for each installation. Raw water is supplied to the water treatment plant where it is pretreated and demineralized prior to being put into the boiler feedwater system. Generally the effluents from the water treatment plants consist of the clarifier blowdown, sand filters and activated carbon filter backwash waters and regenerant effluents from the ion exchangers.

At all stations the effluents are collected in water treatment sumps adjacent to the water treatment plant. The sumps contain agitators and have provision for chemical addition for neutralizing purposes to bring the ph of the effluent to within the acceptable limits of 6.5 to 8.5 before discharge.

At Lakeview, Lambton and Nanticoke the effluents are pumped to either the settling tanks or ash lagoons where they are mixed with the ash effluent and treated as previously described.

At the Bruce Nuclear Generating Station the largest quantity of effluent to be treated is from the water treatment plant producing filtered and demineralized water. Detail studies were carried out prior

to selecting the treatment plant to minimize the effluent discharged from the plant.

Raw water for the treatment plant is drawn from Lake Huron. This has a very low turbidity of 9 ppm as SiO_2 with occasional peaks of 120 ppm or higher under stormy weather conditions.

The water treatment plant process consists of gravity sand filtration followed by activated carbon filtration and multi-stage ion exchange. This design eliminates the usual lime softening clarification unit which is the major source of effluent with suspended solids.

Sand filter backwash water effluents will only contain suspended solids removed from the lake water and residual chlorine from break point chlorination. The carbon filter backwash will contain negligible suspended solids. The backwash water will be discharged directly into the circulating water discharge channel.

Regeneration effluent from the cation and mixed bed exchangers are collected in a two-compartment neutralizing sump of capacities 350,000 gallons and 12,000 gallons respectively. The regeneration effluent will be collected in the larger compartment and the ph adjusted to within 5.5 to 10.6 prior to discharge into the circulating water discharge channel. The smaller compartment will be used for collection of the effluent when repairs to the lining of the large sumps are required during the life of the station.

It is anticipated that although calcium sulphate will be precipitated in the neutralizing sump this will only add 0.5 ppm to the suspended solids of the total circulating water discharge. Further, most of the calcium sulphate will redissolve before reaching the lake.

2. COAL PILE EFFLUENT CONTROL

Stockpiling large tonnages of coal at coal-fired stations gives rise to drains of low ph ranging from 2.8 to 6.5 ph and high iron concentrations ranging from 985 to 38 ppm. In relation to other plant effluents the coal pile drain effluent is very small averaging approximately 40 gpm over the year.

The ph values and iron concentrations are relative to the drainage flow which in turn depends upon the amount of precipitation in a given period. Therefore,

in dry periods small flows with low ph and high iron concentration would be experienced, conversely wet periods would result in large drainage flows of higher ph and lower iron concentrations.

The Ontario Water Resources Commission water quality control objectives specify that all plant effluents are to be treated to give a ph value within the range of 5.5 to 10.6 and to limit the iron concentration to 17 ppm as Fe. To meet these objectives and effectively control water pollution, it is necessary to treat the effluent for ph control and removal of iron.

To control the effluent discharge at Lambton and Nanticoke generating stations, the coal pile drains are collected in sumps and pumped to the ash disposal lagoons where they will react and neutralize while percolating through the ash in the retaining area. This method of control is not possible at Lakeview Generating Station due to restricted land availability.

At Lakeview, preliminary investigations with an experimental installation for ph control using a crushed dolomite bed in the drainage ditch proved unsuccessful. No improvement in ph was noted over a five-week period and a rain storm during this period carried some of the dolomite into the lake. The remainder of the dolomite was covered with coal dust rendering it ineffective as a neutralizing agent. Neutralizing the effluent with crushed limestone or other chemicals was possible but laboratory investigations indicated that the sludge resulting from such treatment had poor settling characteristics and would create further disposal problems. As an interim measure the coal yard drains are being diverted to the condenser circulating water intake channel where they will be mixed with large volumes of the circulating water and the necessary dilution will be achieved prior to discharge through the condenser circulating water outfall.

Further studies are in hand for establishing appropriate treatment processes and control techniques for coal pile effluents. As part of these studies, investigations are being made into the feasibility of incorporating reverse osmosis and electrodialysis processes into the treatment of waste effluents to effect a reduction in the dissolved solids content. These processes were presented in detail in papers read at this Conference in 1970.

3. OIL WASTE EFFLUENT CONTROL

At Lennox G.S. the oil waste effluents may be caused by drainage from rain water runoff in the storage tank farm area and leaks around the oil tank farm forwarding pump rooms and main burner pump forwarding systems. The latter system is located adjacent to the powerhouse.

In the design of fuel oil handling facilities effluent collection and treatment was considered extensively to combat water pollution and meet Ontario Water Resources Commission standards of less than 15 ppm with no visible oil film in the effluent discharged into the lake.

Preliminary design studies were carried out to establish the size and type of equipment required for the effluent treatment. The proposed facilities segregate the effluent to be treated into two main categories:

a) always oily water (AOW)

b) potentially oily water (POW)

AOW is drained from sumps and tanks to the holding pond and will require complete treatment before discharge into the lake. In the treatment plant this water will be passed through a gravity type separator to remove gross oil contamination, followed by an air flotation unit to remove final traces of oil.

If fuel oil analysis shows the presence of phenols, space has been provided for the installation of suitable phenol removal equipment in the future.

The treated effluent will be collected in the batch holding ponds and checked for quality prior to discharge into the lake. Provision will be made to recirculate the effluent by by-passing it to a surge pond of 200 feet x 40 feet x 6 feet deep and back to the treatment plant for further treatment. The arrangement of this system is shown in Figure 20.

POW will include water from dyked areas and storm water runoff from the yard piping areas which, although normally clean may be slightly contaminated due to minor oil spills. This water will normally go into the surge pond where it can be checked for quality before discharge into the lake. If the water requires treatment it will be cycled through the treatment plant. Provision will also be made to pass the POW through the treatment plant if the effluent is definitely known to be contaminated.

The surge pond will be provided with an oil sump and skimmer at the inlet to cope with any accidental oil spillage. Slop oil collected from the gravity type separator, air flotation unit and surge pond will be pumped to a storage tank where the settled water will be decanted and returned to the gravity type separator. The recovered oil will be returned to the tank farm for re-use.

Sludge from the separator and air flotation unit will be pumped into a truck for disposal.

In the tank farm a peak uncontrolled flow rate of approximately 3000 gpm is anticipated during a severe rainstorm, with a rainfall rate of 1.3 inches over a 60-minute period falling on the impervious oil-based surface of the roadway area. The dyked collection areas will be provided with sluice valves used in rotation for controlling the runoff to the surge pond to avoid overloading the treatment plant. The collection in this area is based on a 3-day rainfall of 3.6 inches total falling on the dyked areas. Contingent plans to deal with severe tank farm spillage on an emergency basis are being studied.

4. THERMAL EFFECTS CONTROL

Circulating water is pumped from the station forebay to the condenser which condenses the exhaust steam from the turbine prior to it being returned to the boiler. The latent heat of the steam is transferred to the circulating water, increasing the temperature proportional to the amount of heat transfer surface in the condenser. In existing installations the rise varies between $15^{o}F$ and $26^{o}F$.

A temperature rise of not more than $19^{o}F$ is being used by Ontario Hydro for design of future stations on the Great Lakes. Such an increase in temperature brings the discharged cooling water into a range where it is believed that no significant adverse effects will occur to the lake environment, based on available experimental data. The temperature rise can be controlled by either specifying a condenser with a combined surface area and tube length to meet this criteria or by providing a tempering water system. This system consists of pumps which discharge the lake water from the forebay into the circulating water discharge channel, where it is mixed with the condenser discharge in sufficient quantities so that the mixed water discharge temperature to the lake is within the prescribed limits.

At Lakeview, Douglas Point, Pickering and Bruce G.S. the condensers are sized to give a temperature rise no greater than 18°F.

At Nanticoke and Lennox G.S. tempering systems are installed to limit the temperature rise to 15°F and 18°F respectively. The existing Lambton station has a maximum temperature rise of 26°F. This heat is quickly dispersed in the large rapidly moving St. Clair River flow.

CONCLUSION

It is evident from the foregoing that Ontario Hydro is carrying out and planning extensive programs of studies at its generating stations on the Great Lakes. From these studies, environmental data will be gathered and factual information obtained as to any effects on the environment of waste heat emissions from the plants. This information will be of direct value to Ontario Hydro in improving station design so that environmental impact is minimized. In addition, the results of these investigations will provide the regulatory agencies with information necessary for the selection of rational criteria with respect to waste heat emissions.

With regard to water quality control, Ontario Hydro will continue to study new and more efficient methods of treating plant effluents. As standards become more stringent and problems more complex, large expenditures will be committed to provide for research, testing and installation of the type of equipment described in this paper. Ontario Hydro is well aware of its responsibilities in this area.

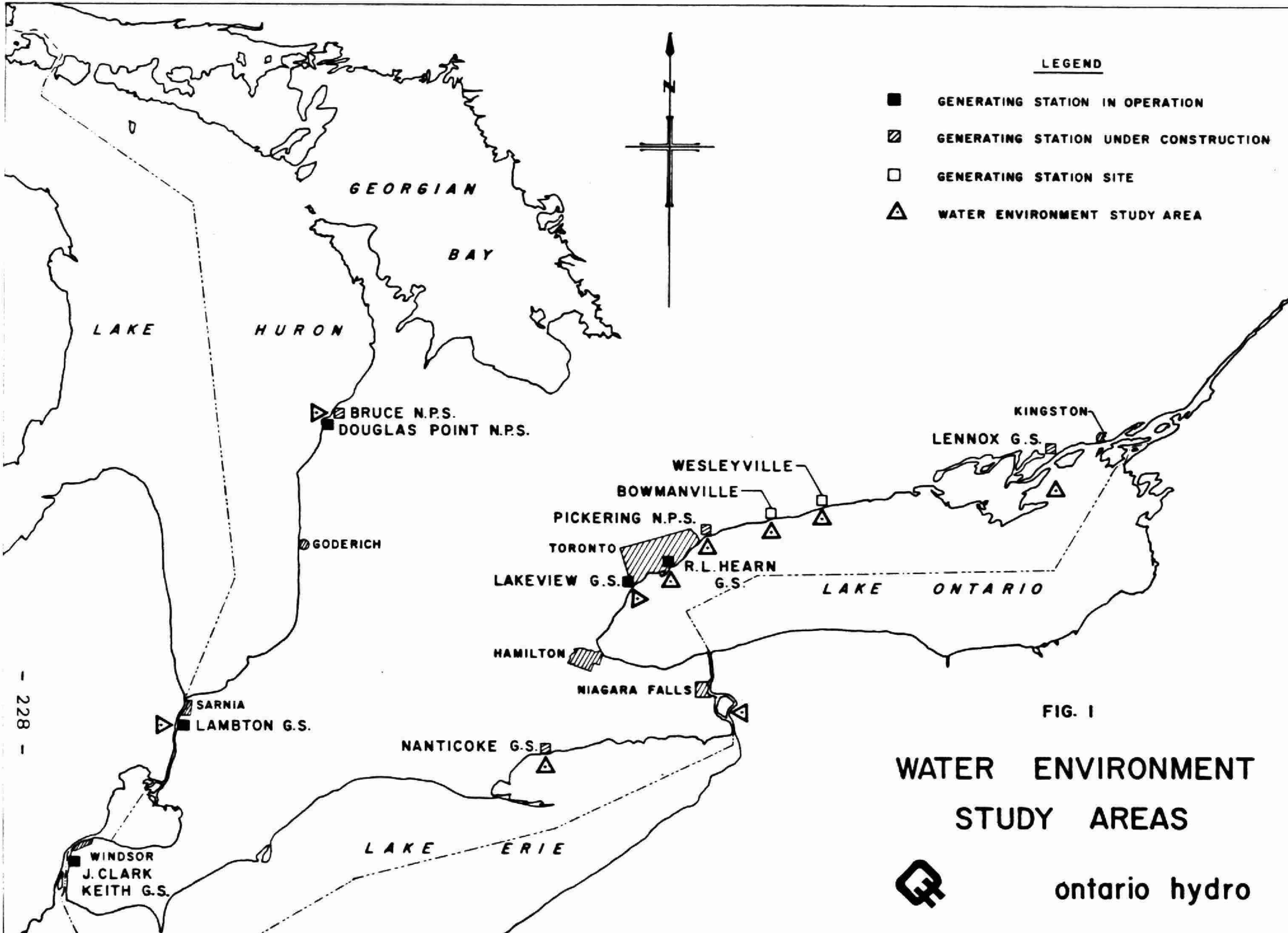
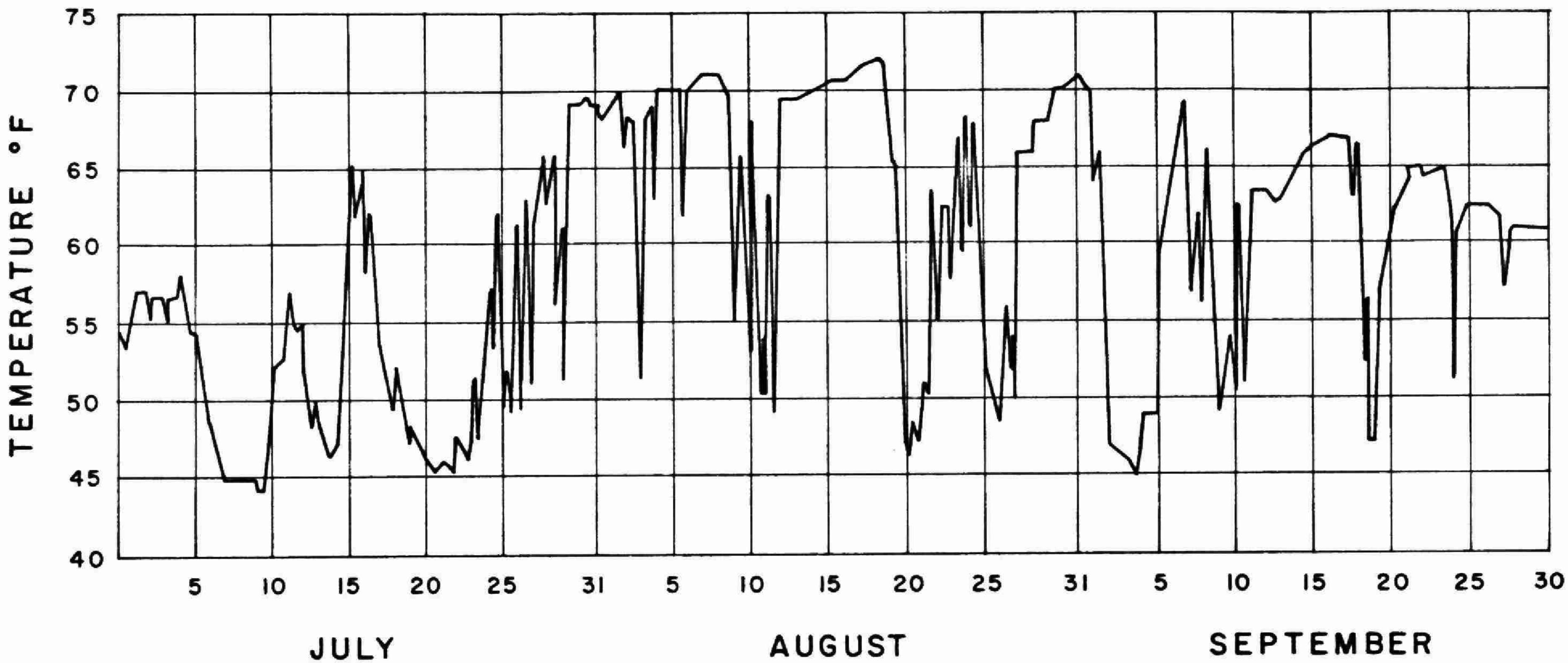


FIG. 1

WATER ENVIRONMENT STUDY AREAS



1969

FIG. 2

RECORDED 3000 FEET NORTH OF DOUGLAS POINT

2200 FEET FROM SHORE AT 40 FOOT DEPTH

BY THERMOGRAPH

LAKE HURON
WATER TEMPERATURE

ontario hydro

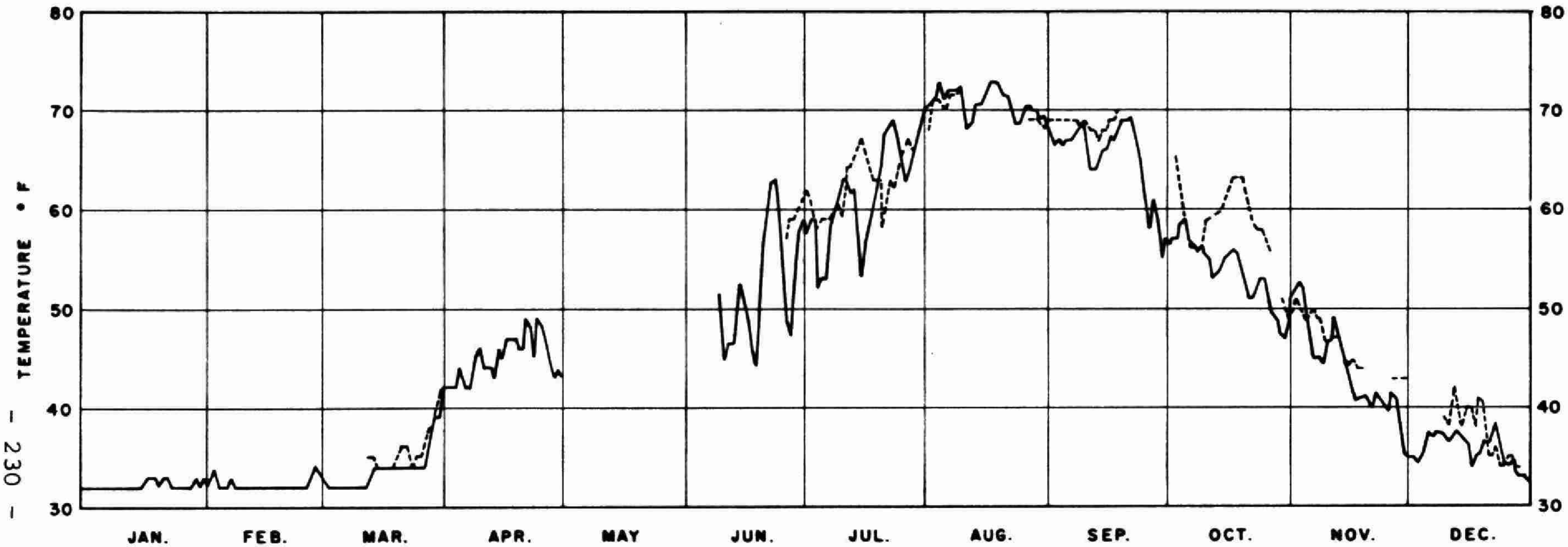


FIG. 3

LAKE ERIE

DAILY MEAN WATER TEMPERATURE

AT NANTICOKE G.S.

1967-1968

RECORDED AT JARVIS PUMP HOUSE
INTAKE 1,000 FEET FROM SHORE
AT 25 FOOT DEPTH BY THERMOGRAPH.

LEGEND

——— 1967

- - - - 1968

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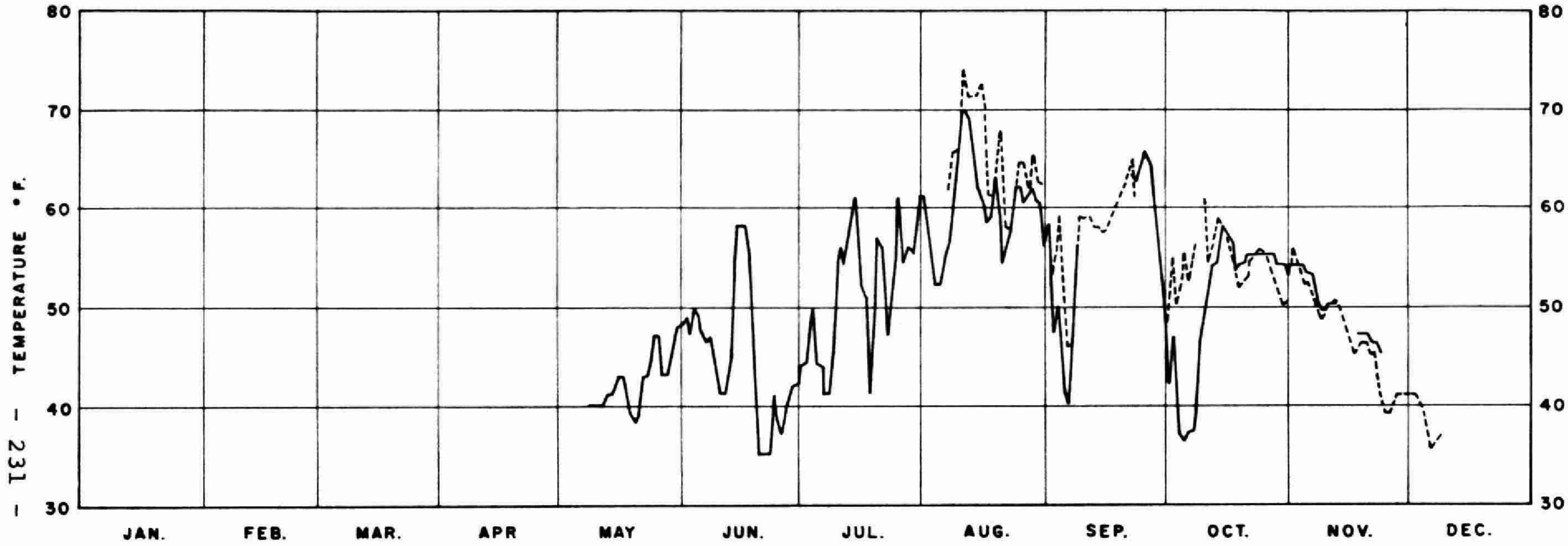


LEGEND

RECORDED AT 26 FOOT DEPTH, 5,000 FEET OFFSHORE.

RECORDED AT 5 FOOT DEPTH, AT GENERATING STATION, NEAR SHORE.

FIG. 4

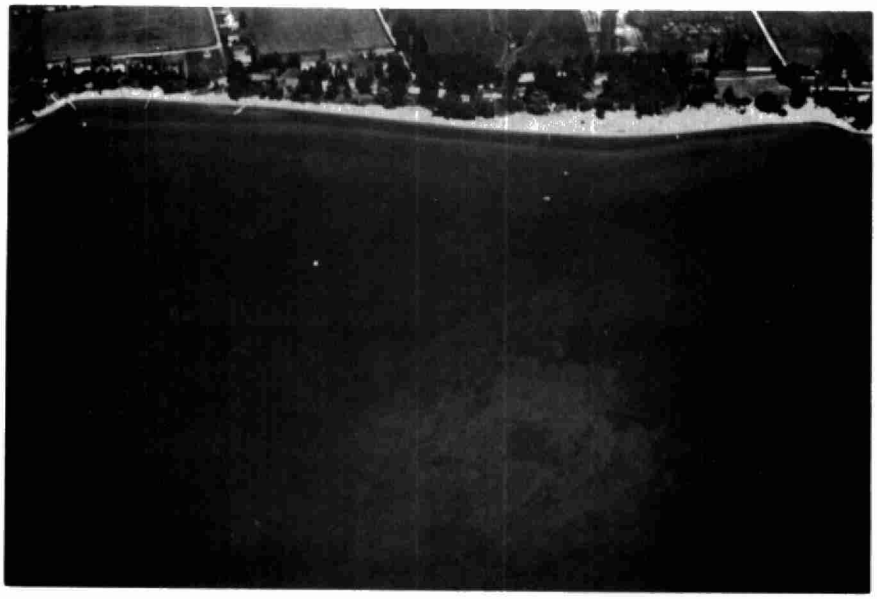
LAKE ONTARIO
DAILY MEAN WATER TEMPERATURE
AT PICKERING G.S.
1970

ontario hydro

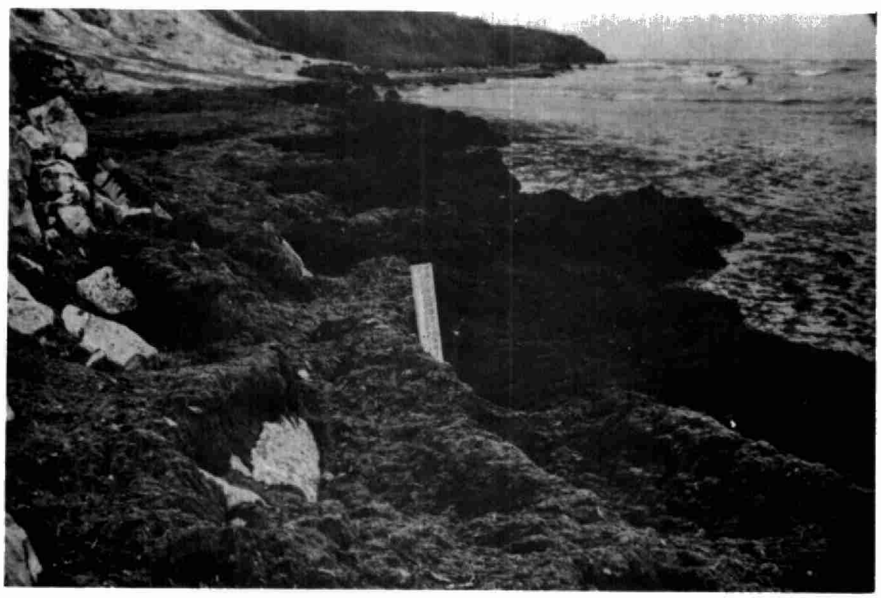
Ice Barrier 800 feet offshore near
Douglas Point Intake

Large Ice Barrier 1,000 feet offshore
South of Douglas Point

Fig. 5. ICE CLIFFS IN LAKE HURON

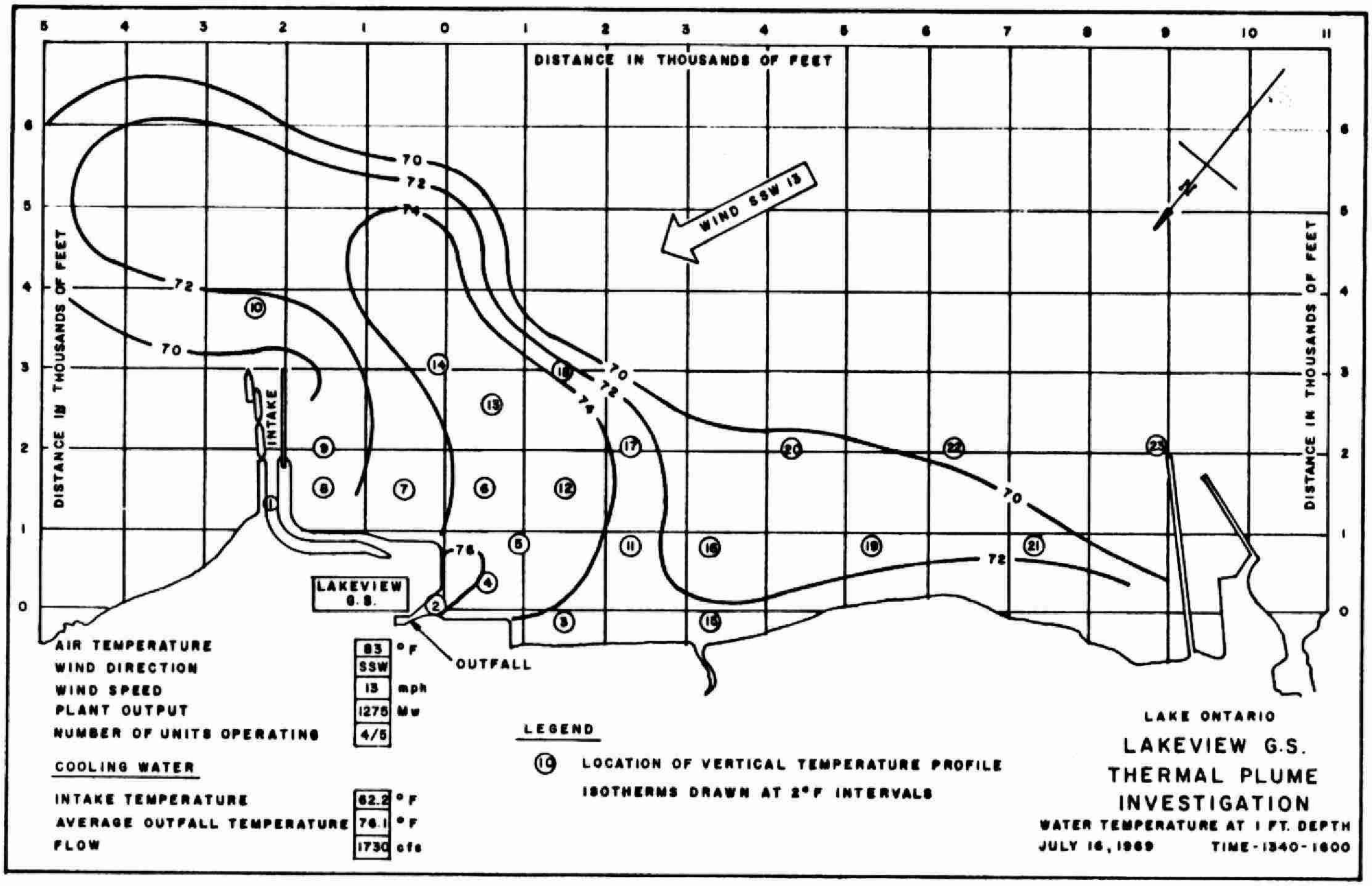


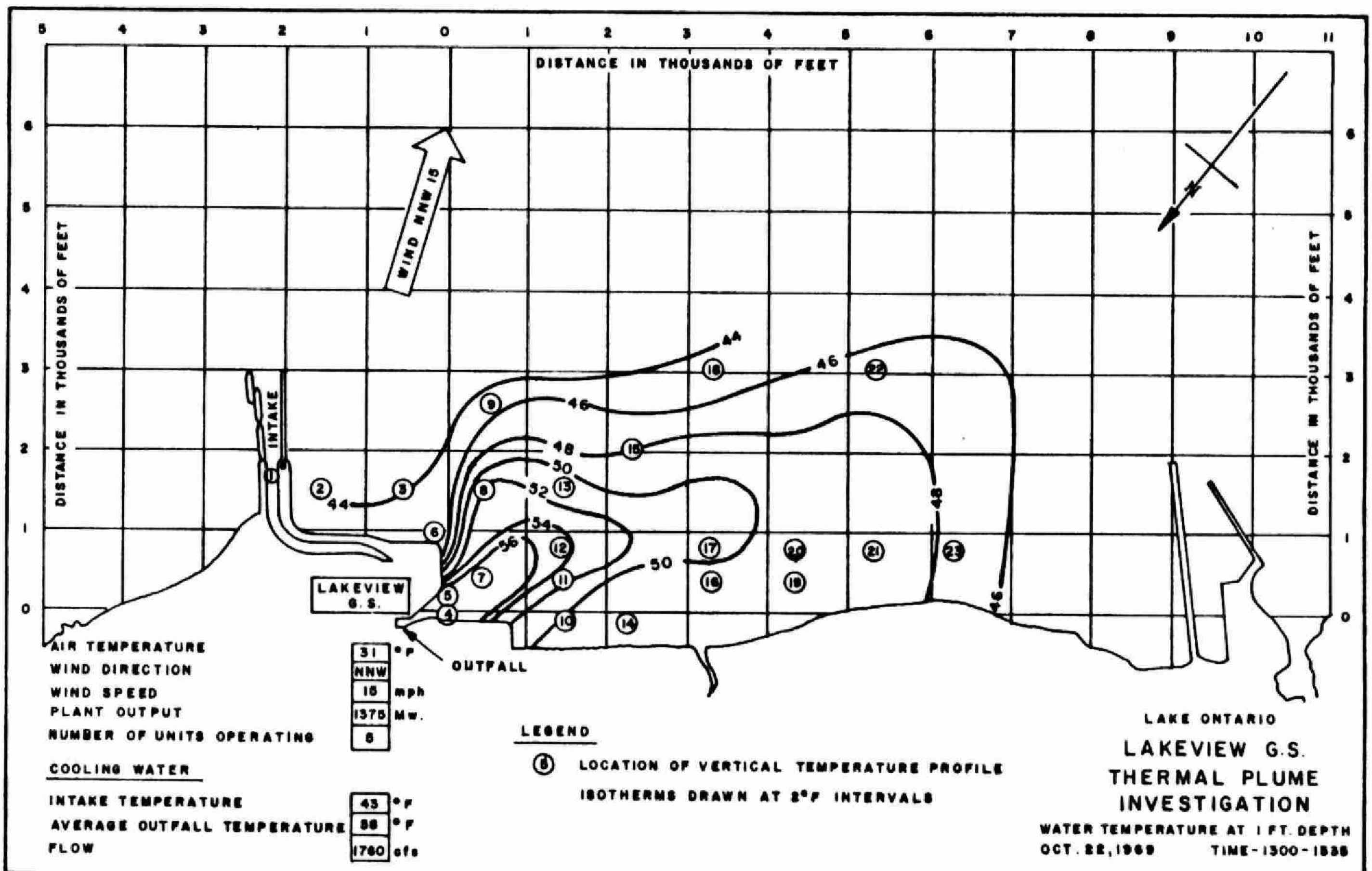
Aerial View of
Weed Bed in Lake Erie off Nanticoke



Accumulation of Dead Weeds on Shore
near Pickering, Lake Ontario

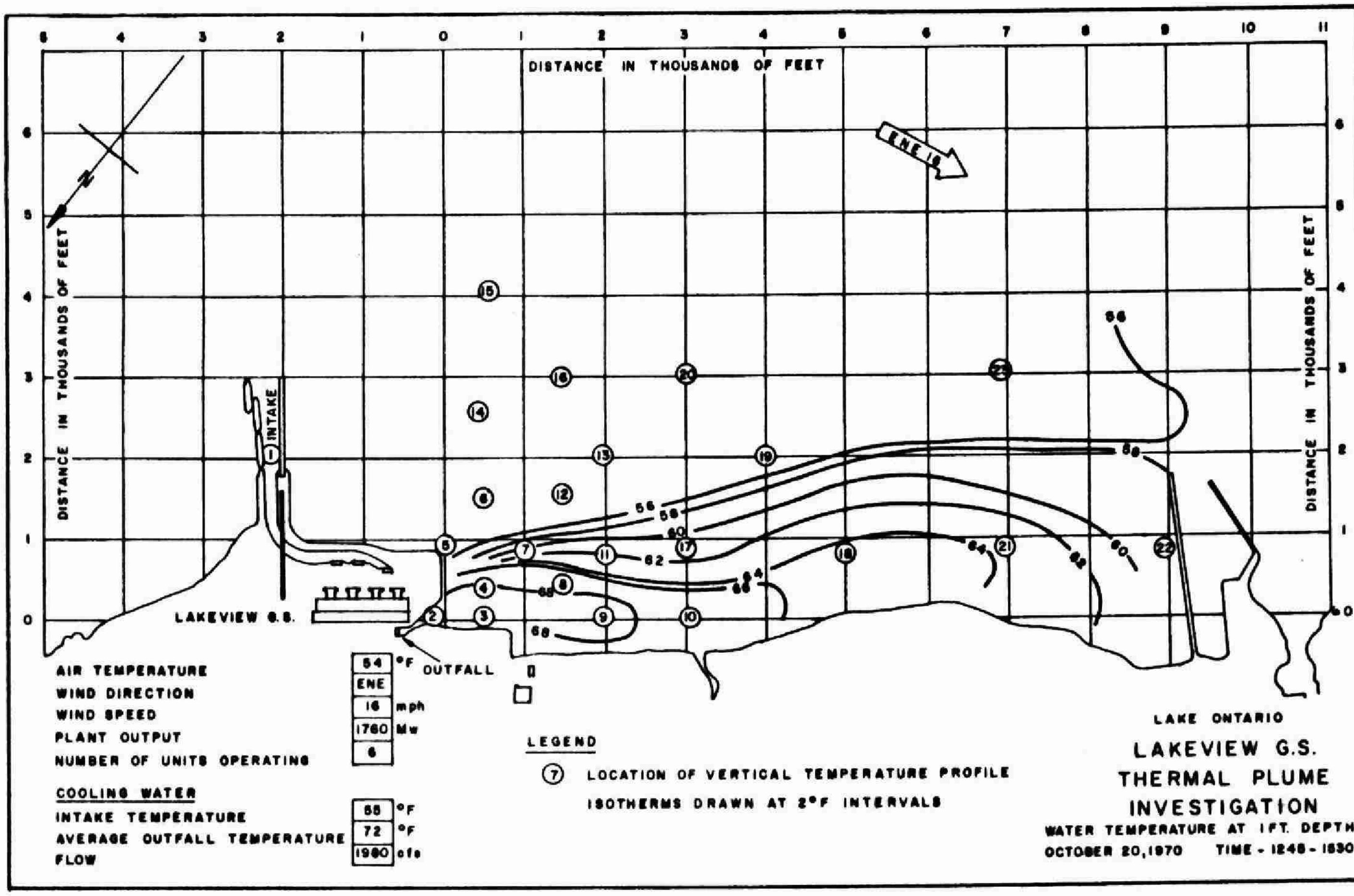
Fig. 6 AQUATIC WEED OBSERVATIONS

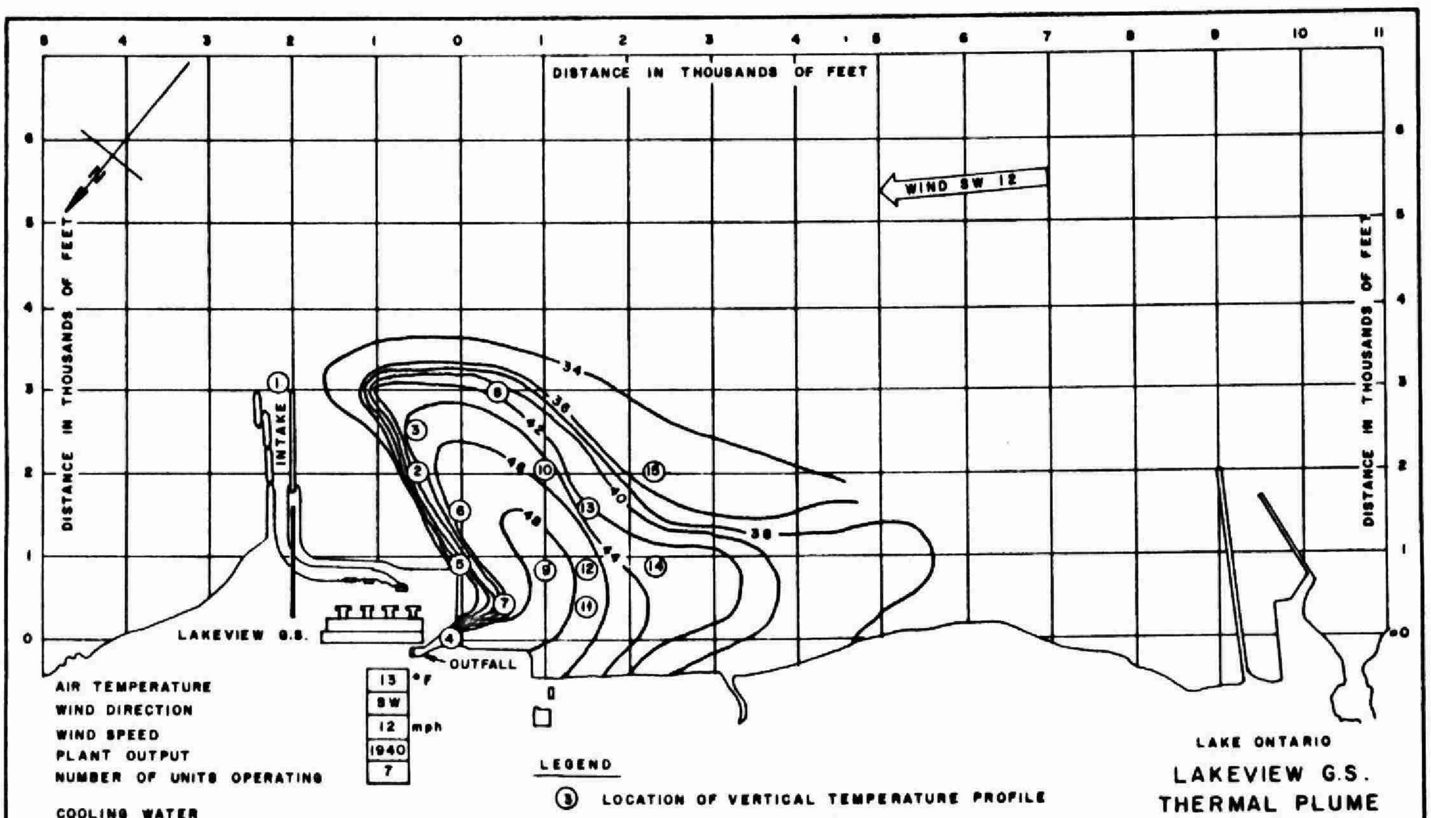




ISOTHERMS WITHIN THERMAL PLUME ON SELECTED DAYS

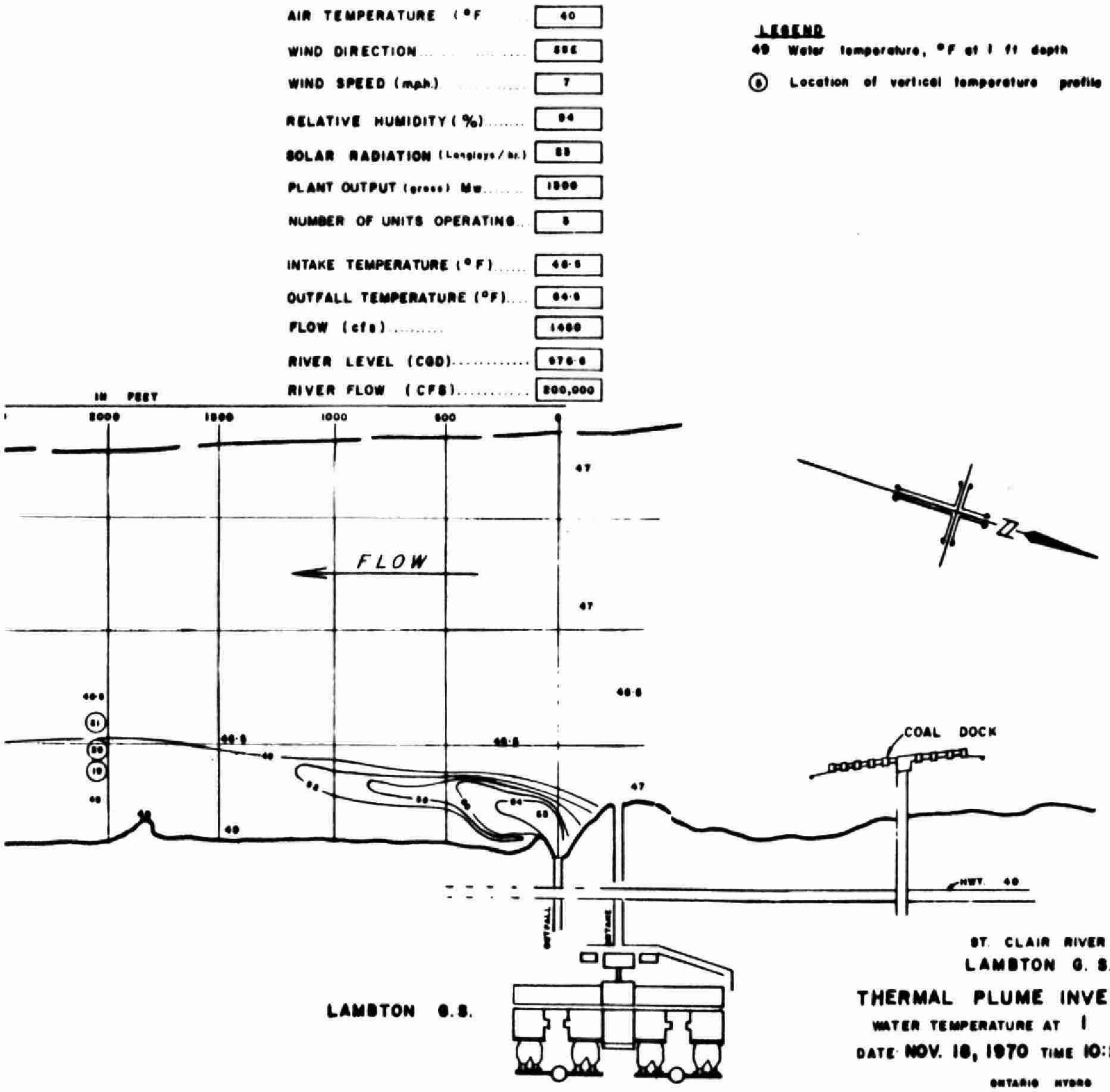
FIG. 7





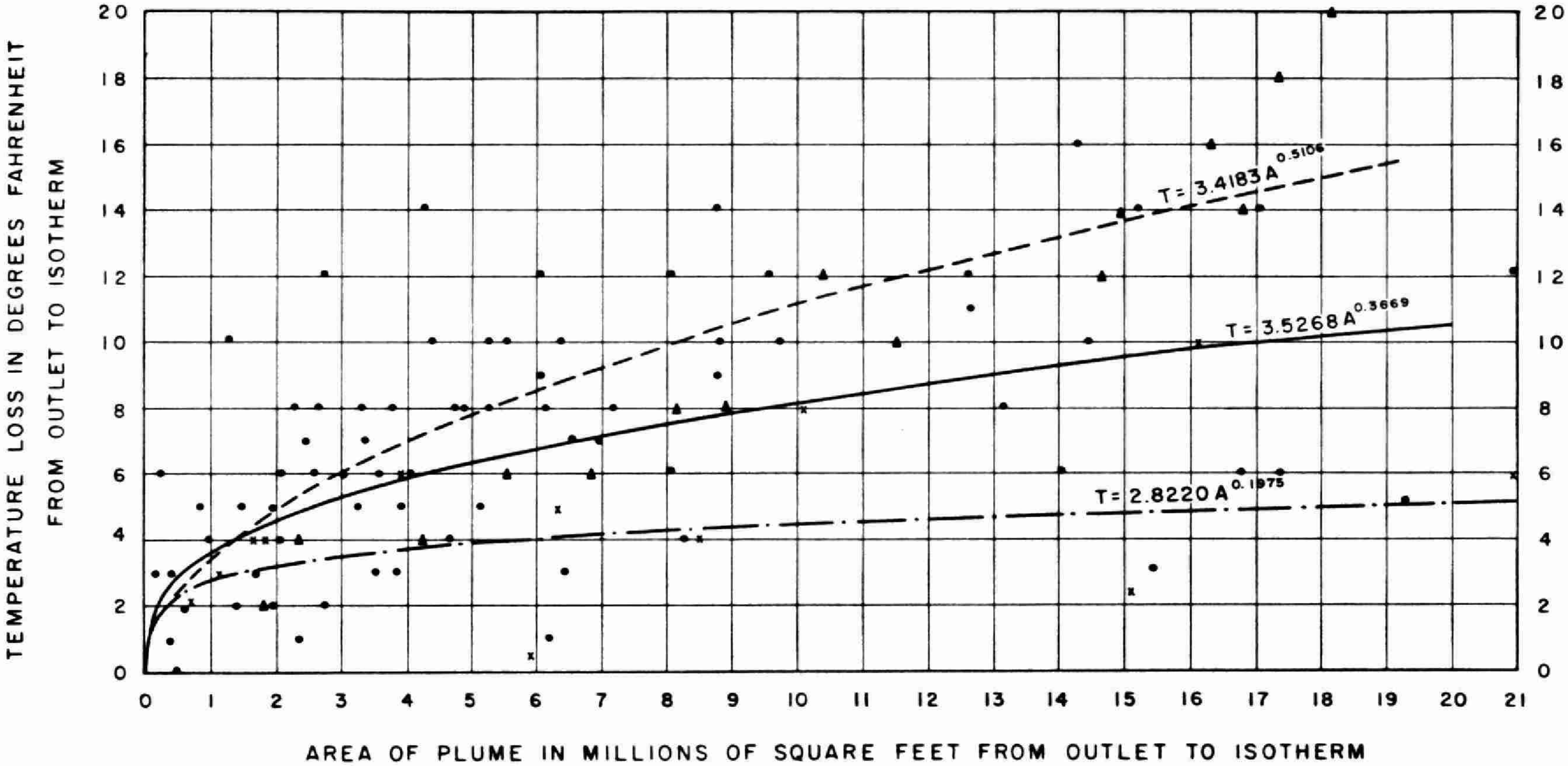
ISOTHERMS WITHIN THERMAL PLUME ON SELECTED DAYS

FIG. 8



ST. CLAIR RIVER
LAMBTON G. S.
THERMAL PLUME INVESTIGATION
WATER TEMPERATURE AT 1 FT. DEPTH
DATE NOV. 18, 1970 TIME 10:20 — 12:46
ONTARIO HYDRO
HYDRAULIC STUDIES DEPARTMENT

FIG. 9



LEGEND

•	SPRING AND FALL	———	APR., MAY, JUN., SEP., OCT., NOV.
x	SUMMER	—·—	JUL., AUG.
▲	WINTER	– – – –	DEC., JAN., FEB., MAR.

NOTE - OBSERVATIONS MADE DURING PERIOD MAY 1969 TO OCT. 1970.

LAKEVIEW G.S.

OBSERVED RELATIONSHIP BETWEEN PLUME AREA AND TEMPERATURE LOSS

ontario hydro

FIG. 10

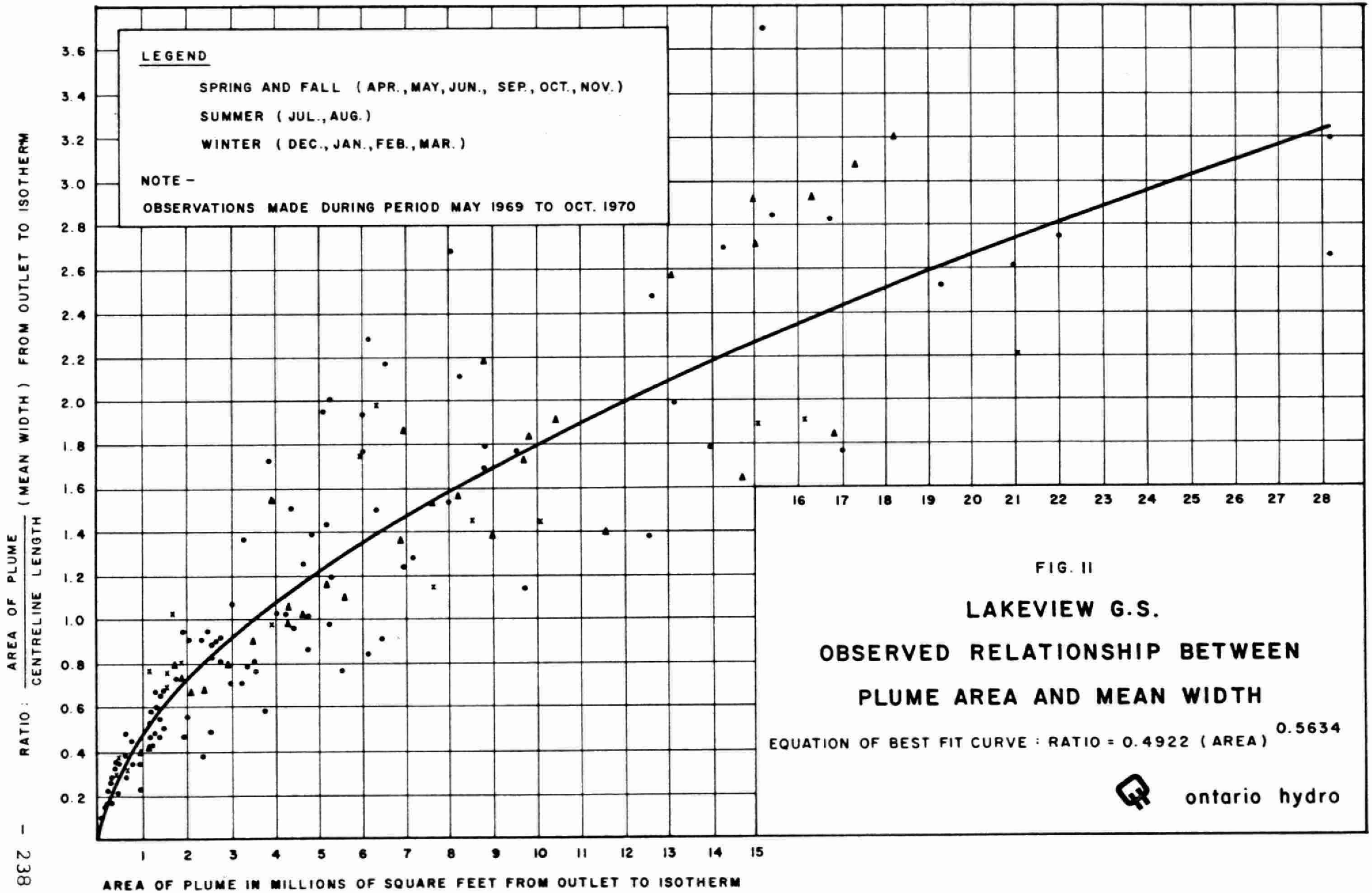
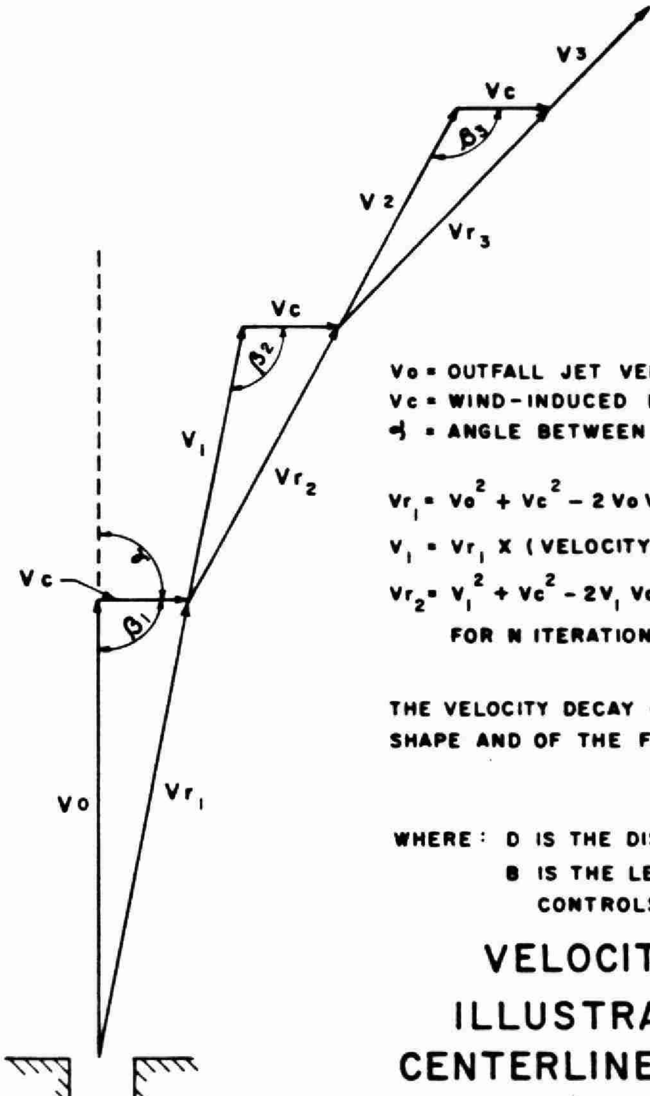


FIG. 11

LAKEVIEW G.S.

OBSERVED RELATIONSHIP BETWEEN PLUME AREA AND MEAN WIDTH

EQUATION OF BEST FIT CURVE : $\text{RATIO} = 0.4922\ (\text{AREA})^{0.5634}$



Vo = OUTFALL JET VELOCITY.
Vc = WIND-INDUCED LAKE CURRENT.
α = ANGLE BETWEEN JET AND WIND DIRECTION.

$Vr_1 = Vo^2 + Vc^2 - 2\,Vo\,Vc\,\cos\beta$

$V_1 = Vr_1 \times$ (VELOCITY DECAY FUNCTION)

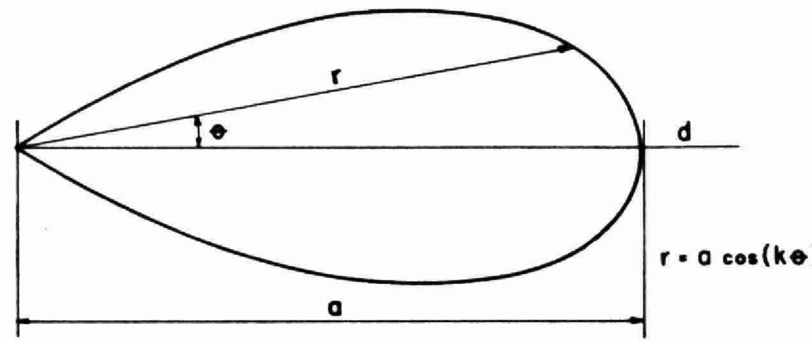
$Vr_2 = V_1^2 + Vc^2 - 2V_1\,Vc\,\cos\beta^2$ ETC.

FOR N ITERATIONS.

THE VELOCITY DECAY FUNCTION IS A LORENTZIAN SHAPE AND OF THE FORM $\dfrac{B^2}{D^2 + B^2}$

WHERE: D IS THE DISTANCE ALONG PLUME ℄
B IS THE LENGTH PARAMETER WHICH CONTROLS THE RATE OF DECAY.

VELOCITY DIAGRAM ILLUSTRATING PLUME CENTERLINE CALCULATION



AREA = A = $\dfrac{\pi}{4}\dfrac{a^2}{k}$

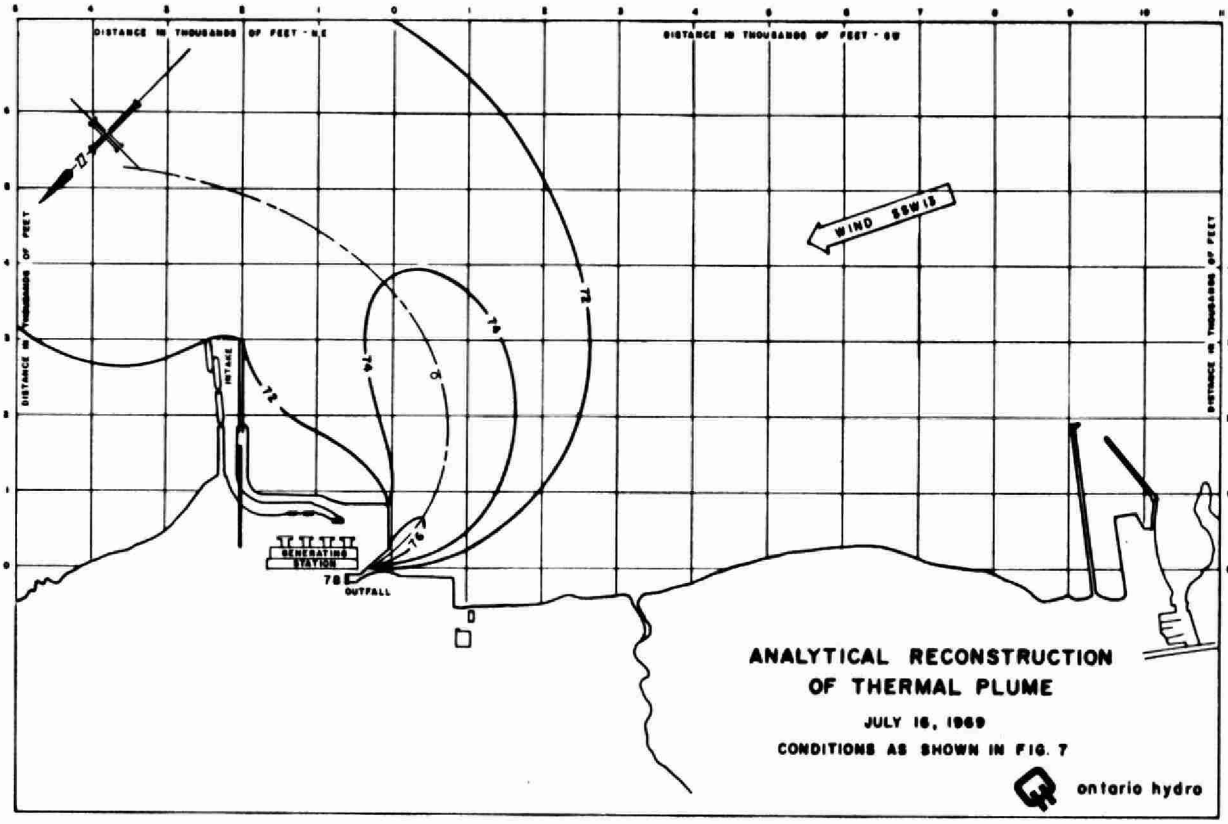
WHERE RATIO = R = $\dfrac{A}{a}$

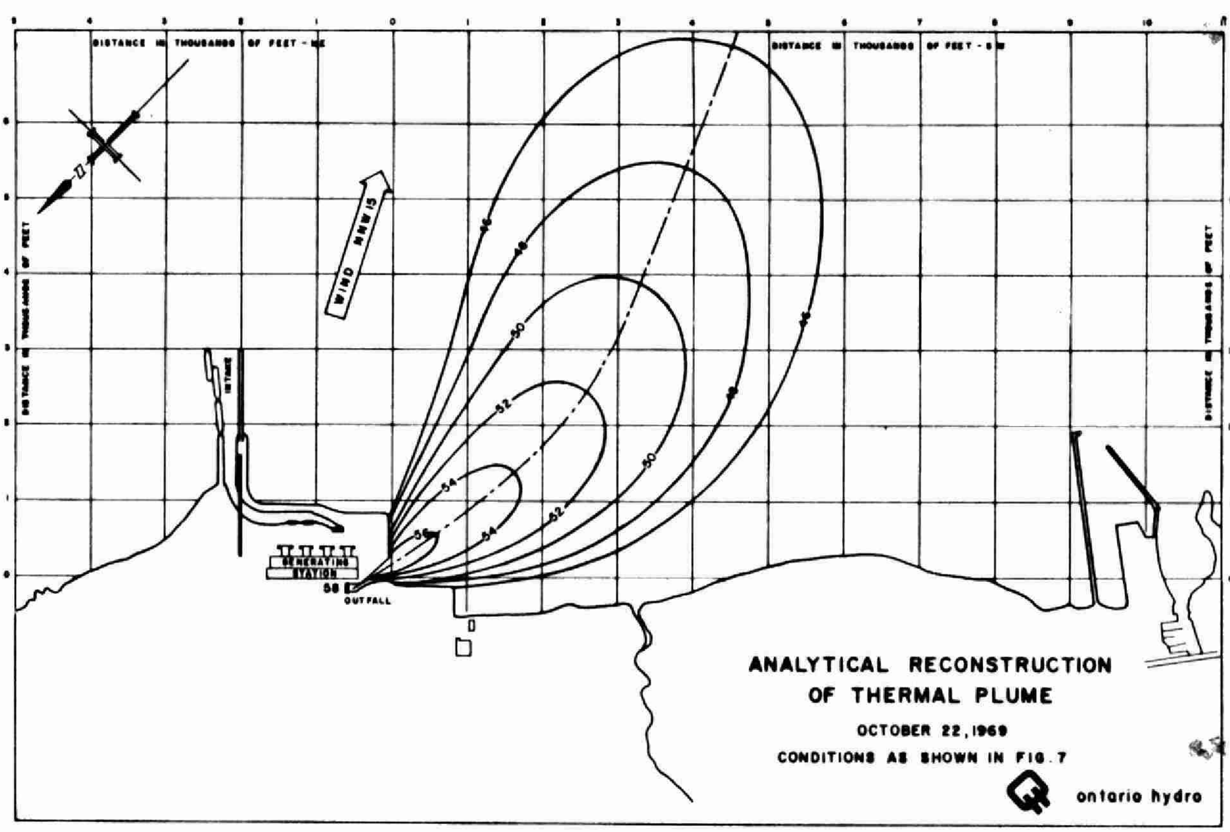
THUS $k = \dfrac{\pi}{4}\dfrac{A}{R^2}$

LEMNISCATE IN POLAR FORM

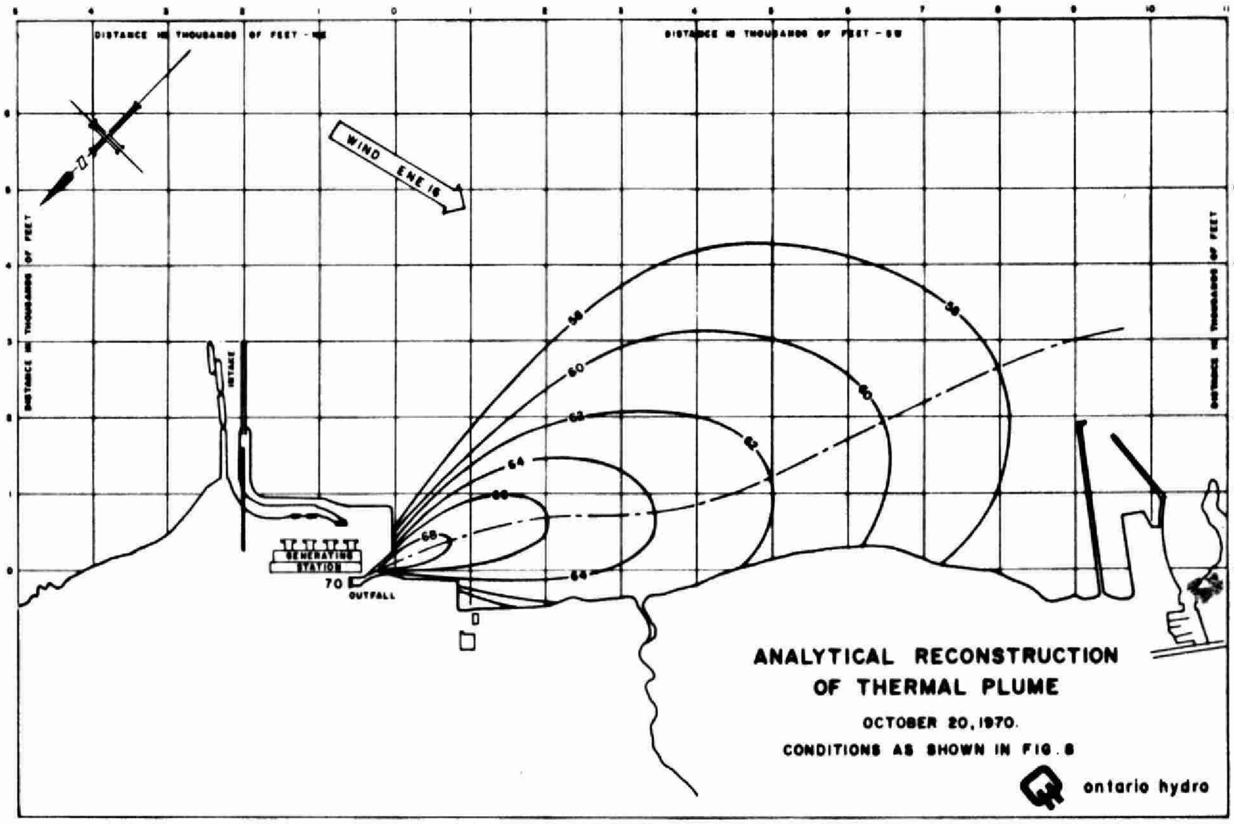
ontario hydro

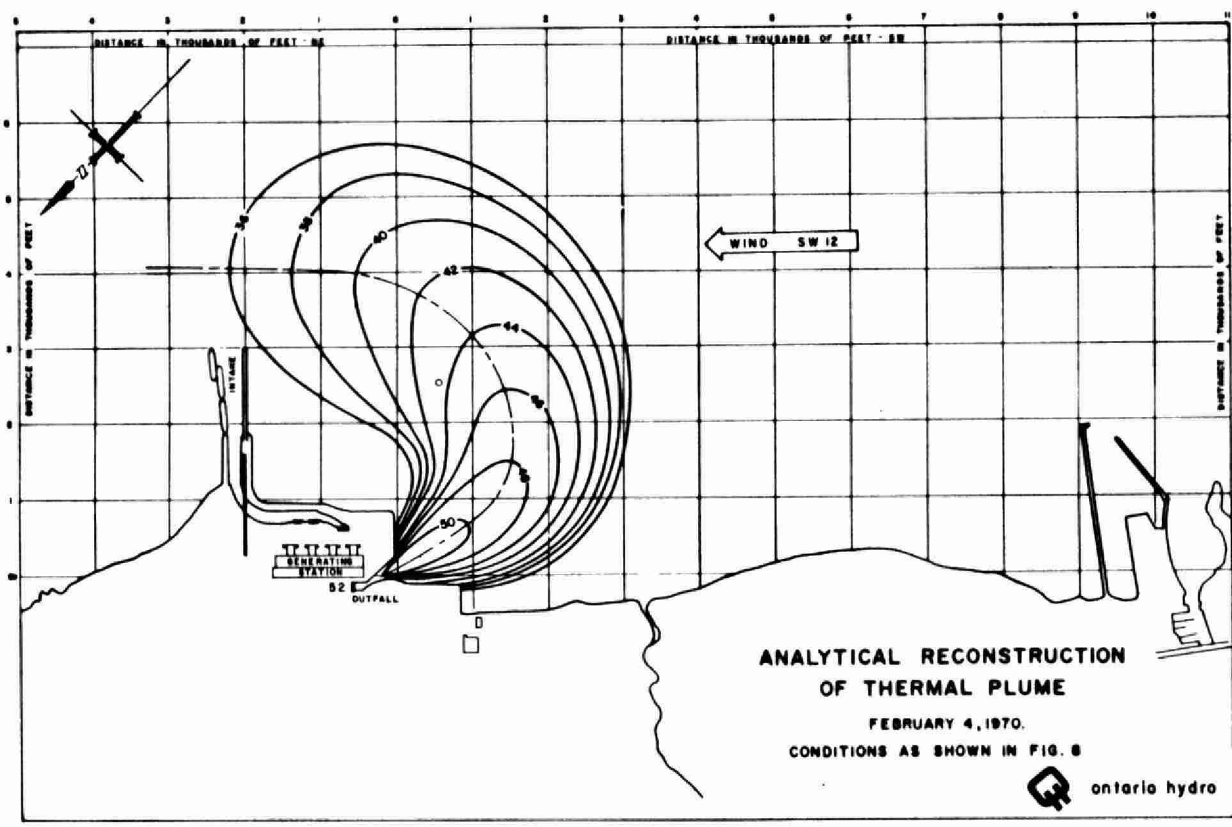
FIG. 12





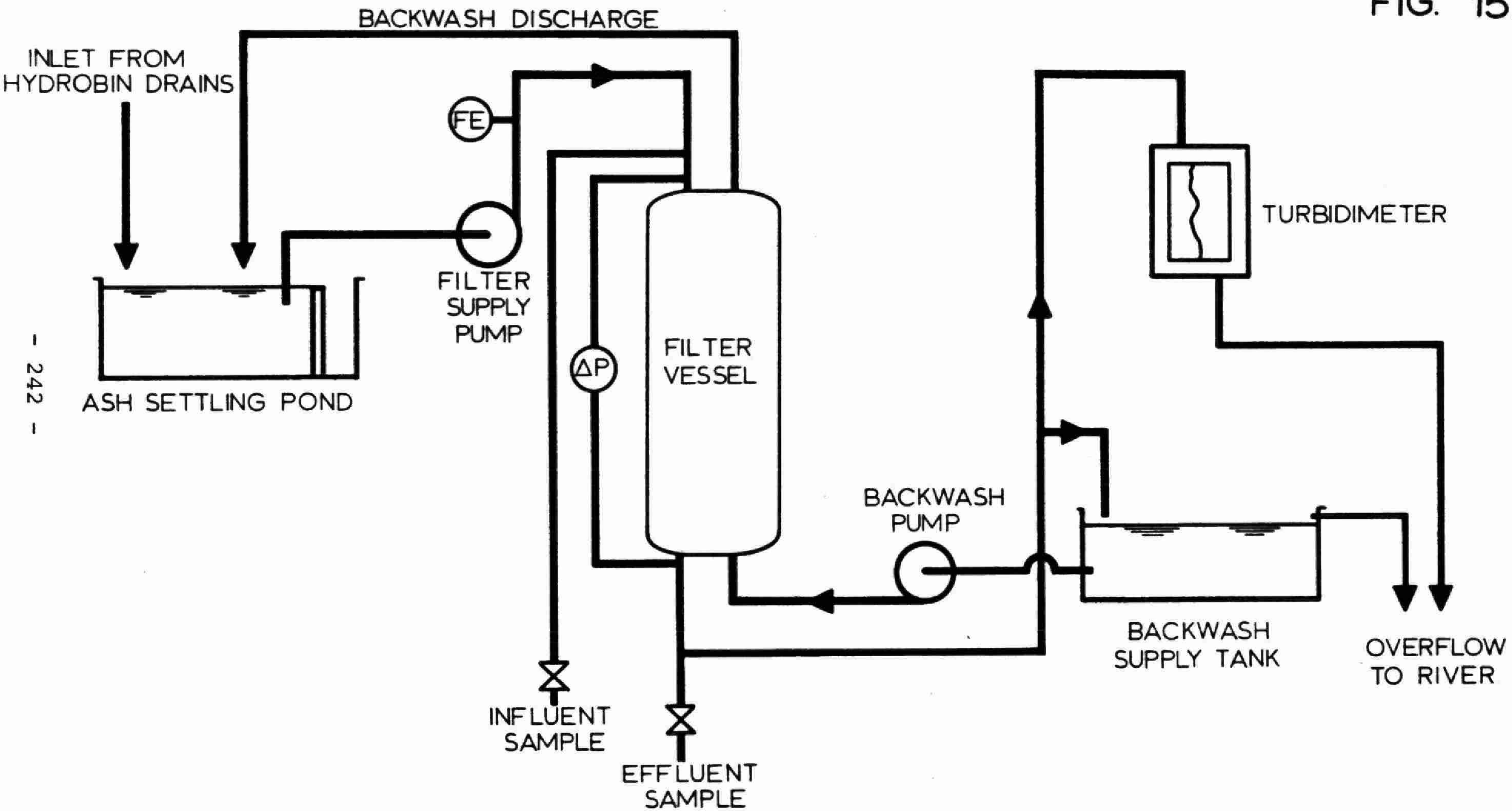
RECONSTRUCTED THERMAL PLUMES ON SELECTED DAYS FIG. 13





RECONSTRUCTED THERMAL PLUMES ON SELECTED DAYS FIG. 14

FIG. 15.



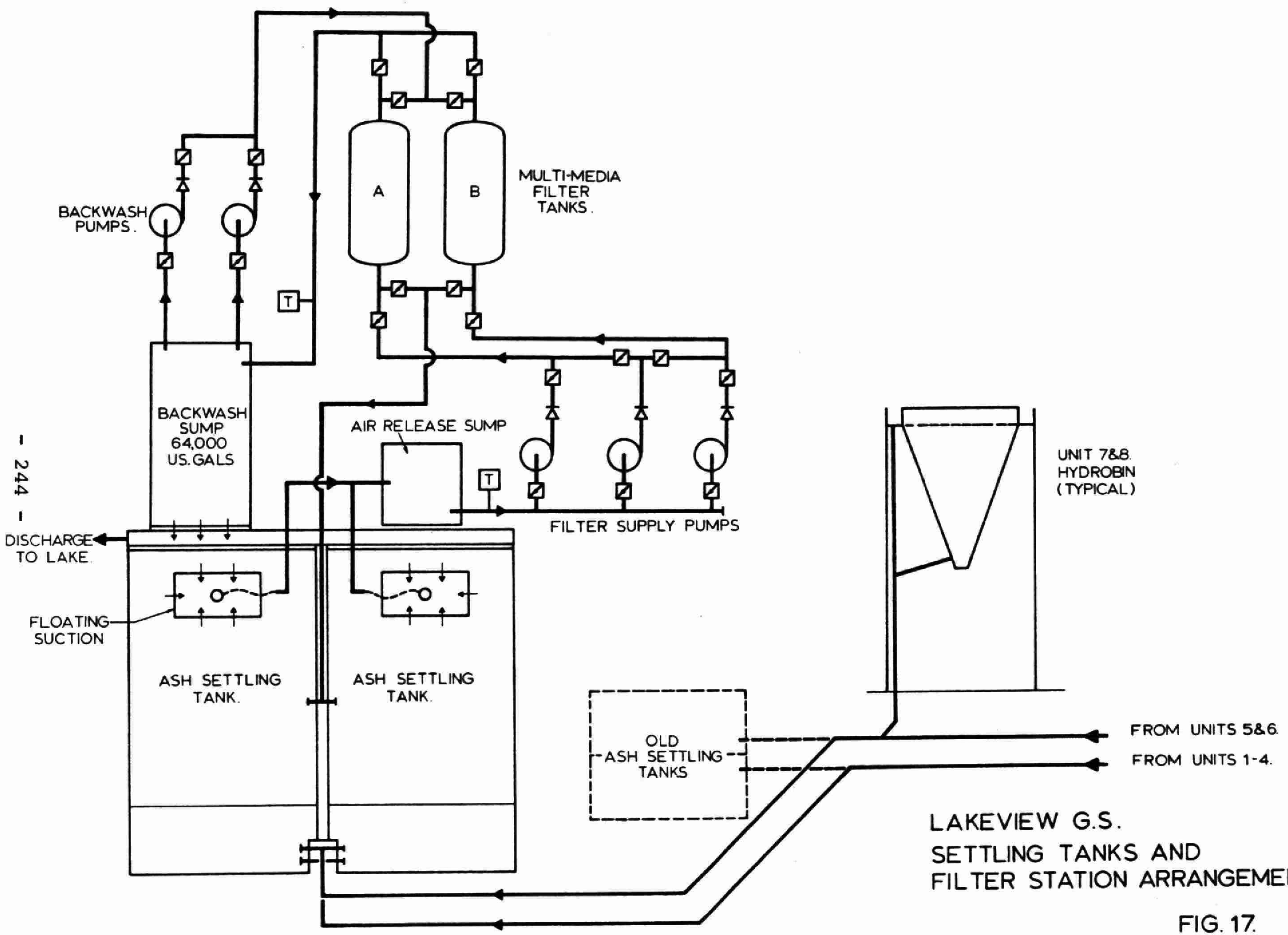
PILOT EFFLUENT FILTER PLANT - LAMBTON G.S.

PILOT FILTER DATA.

FIG.16.

TEST 10.-FLOW 10 USGPM/SQFT -NO CHEMICAL.

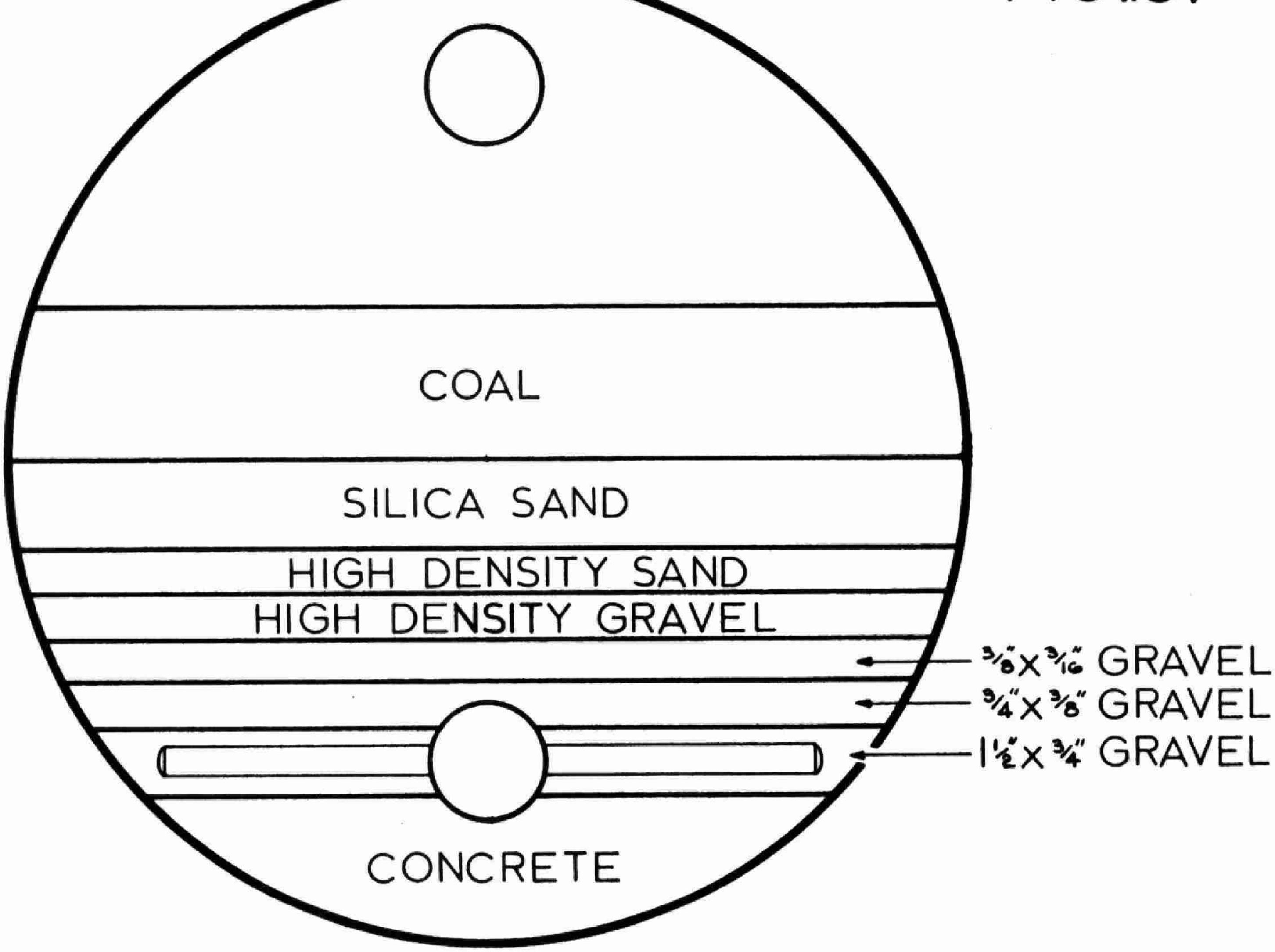
DATE	TIME	CONCENTRATION (ppm)		REMARKS
		INFLUENT	EFFLUENT	
MAY 11/70.	14:00	73.8	10.0	
	18:00	11.2	0	
	22:00	68.4	8.0	
MAY 12/70	02:00	49.0	14.2	ASH SLUICING
	06:00	23.2	5.2	
	09:30	9.6	2.4	
	14:00	145.2	10.6	
	16:00	15.8	4.8	
	20:00	52.4	3.2	
	24:00	27.4	2.0	ASH SLUICING
MAY 13/70	04:00	36.0	6.4	
	08:00	25.4	4.8	
	12:00	62.2	18.8	ASH SLUICING
	16:00	17.0	1.2	
	22:00	36.0	6.6	
MAY 14/70	02:00	52.2	5.8	ASH SLUICING
	06:00	26.4	4.8	
	10:00	41.4	13.8	ASH SLUICING
	14:00	38.8	4.4	
	18:00	83.6	6.0	
	22:00	64.6	4.6	



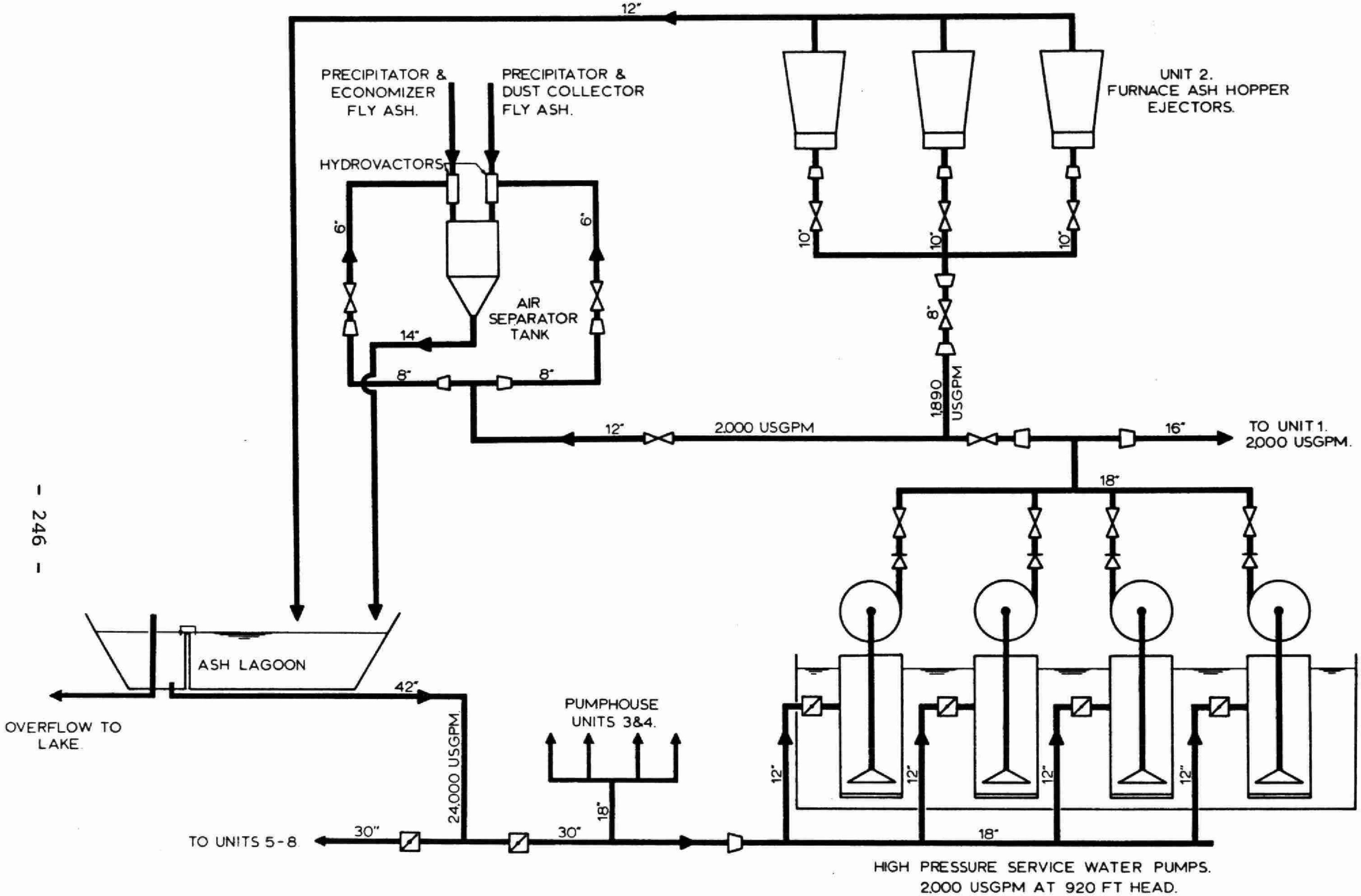
LAKEVIEW G.S.
SETTLING TANKS AND
FILTER STATION ARRANGEMENT.

FIG. 17.

FIG.18.



SECTION: MULTI-MEDIA FILTER.
LAKEVIEW G.S.



NANTICOKE G.S. ASH TRANSPORT SYSTEM. FIG. 19.

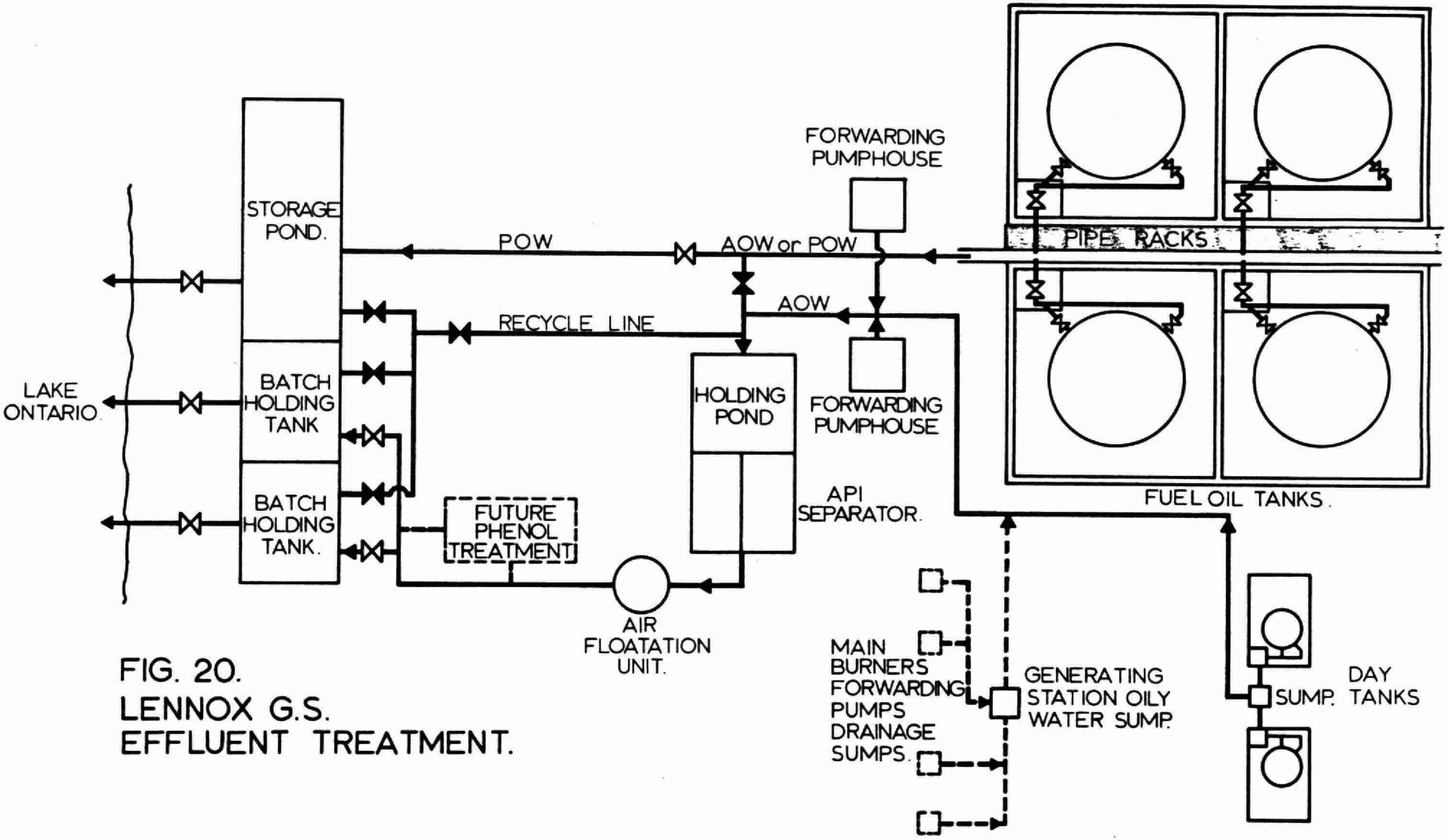


FIG. 20.
LENNOX G.S.
EFFLUENT TREATMENT.

EIGHTEENTH ONTARIO INDUSTRIAL WASTE CONFERENCE

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